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ABSTRACT

This guide to the economic analysis of media use in education reviews the evidence on the costs and benefits of educational media and provides a methodology for future decision-making. It includes chapters on establishing a framework for media choice, evaluating the effectiveness of media use, and analyzing costs. The empirical evidence from past projects is chosen to illustrate both different types of media projects and different methodological approaches. Among the projects discussed are the Open University in Great Britain, the Telesecundaria project in Mexico, the Nicaraguan Radio Mathematics Project, the State University Resources for Graduate Education (SURGE) at Colorado State University, and the PLATO computer-assisted learning project in the United States. The final chapter draws on the evidence of past projects to discuss why many media innovations seem to fail and what is required to make such innovations more effective, thus turning their potential cost and educational benefits into reality. Notes, a 5-page reference list, and a topic index are included. (Author/LMM)

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THE ECONOMICS OF EDUCATIONAL MEDIA

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To Jennifer, Mark and Sharon

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Preface

My interest in the economic implications of using new media in education began some ten years ago when I was appointed to an economics lectureship at the Open University. The University challenged many of the assumptions of traditional higher education and because of that it attracted a great deal of (sometimes sceptical) attention. One of the areas it challenged was the cost implications of providing higher education. In economists' language the Open University's media-based distance learning system changed the production function of higher education. The clear and almost linear relationship between staff and student numbers which was the primary determinant of cost no longer applied. In cost terms the Open University system of producing courses is to higher education what Henry Ford was to motor car production. It offers a mass production alternative to the traditional craft approach.

One of the things I became aware of as a result of my early work on the comparative costs of the Open University and traditional higher education was that there was a limited insight to be gained from studying the costs of *the* Open University. The results obtained, which were very favourable in cost terms to the University, were the result of its particular media mix. The Open University itself could be made cheap or expensive within very broad limits by making small adjustments to its media mix or changing its student numbers. The wider study of the cost implications of using media in education seemed to be a much more interesting approach.

And so it has turned out to be. Almost every project I have studied round the world either at first hand or through the work of others has added to my understanding. During the seventies, interest in these cost implications increased through the work of international organisations such as UNESCO and the World Bank which are heavily involved in sponsoring projects in the developing areas of the world. I have been privileged to participate in some of this work and have learnt a great deal from it.

This book then is a distillation of what I have learnt from my own work and that of others over the past decade. As I explain in the text I believe there will be a growing interest in the use of media in education during the eighties despite (or indeed because of) the problems facing the economies of many countries. The crucial question for the future is how can we make such media use more effective? I believe an understanding of the economic approach is an important contribution to part of the answer. It is my hope that policy-makers and managers of media systems will gain insights that enable them to make more effective decisions and that my fellow economists will appreciate the application of economic analysis to an unusual area.

Virtually everyone I have spoken to on this subject over the past decade will have had some influence on what appears here, and it is difficult to single out individuals for special mention. Many I'm sure in any case would not wish to be found guilty by association. I must however give special thanks to the following: Richard Layard was very helpful in the early days in introducing me to the literature and making available the facilities of the Higher Education Research Unit at the London School of Economics. Keith Lumsden also encouraged my early work and guided me to the work being done in the USA. The Social Science Research Council provided me with a small grant to pursue this work.

As to the book itself, David Hawkridge read through early drafts and provided constructive criticisms, particularly on Chapter 2. I suspect however that he is still unhappy with parts of it. More than anything I have benefited from discussions over a long period with colleagues in the USA. To Dean Jamison, Stuart Wells and Steven Klees my grateful thanks. Although they have had no direct involvement in the book they will recognise their influence. However they will be the first, I'm sure, to join with the others in echoing the usual disclaimer that all responsibility for what appears here is mine. A final thanks to Jenny, Mark and Sharon for tolerating my obsession with a rather esoteric subject that must have seemed an almost permanent lodger in our home. By now I think they are reconciled to the tenancy continuing.

Leslie Wagner

1 Introduction

ECONOMICS AND EDUCATIONAL MEDIA

During the past two decades there has been what can only be described as an explosion in the use of media in education. The range is enormous. There is hardly an educational institution, certainly in the advanced economies, which does not have some form of audio-visual equipment. The use of media ranges from *ad hoc* materials, to enrich normal teacher-mediated instruction, to a comprehensive and systematic use of different media approaches as an integral part of an instructional system as is found, for example, in the UK Open University. Media use in education is, of course, not new. The media themselves (principally radio, television and film) were all developed commercially during the first half of the century and soon found their way into schools. In the UK, for example, the BBC began its Schools Broadcasts in 1924 and educational television was introduced in 1957.

Two features, however, have come to prominence in the 1960s and 1970s. The first is the growing international nature of media use. Side by side with its more intensive use in advanced economies has been the growing use of media in developing countries. International aid agencies such as UNESCO, the World Bank and the United States Agency for International Development have recognised the potential of media for raising educational levels, particularly in the developing country context of geographical difficulties and specialist staff shortage.

A second feature of the recent past is the increasing cost of instructional media systems. Whilst improved technology and larger-scale production has reduced the price of individual pieces of media equipment the systems which incorporate this equipment have grown larger. In many cases projects involve many millions of dollars to establish and run. The Open University for example after 7 years was involved in an annual expenditure close to 50 million dollars.

So the size and the scope of media use in education are reasons enough for an economic study. Recognition of the need for an economic dimension to the evaluation of media systems was, however, slow to develop. Studies began in the sixties but it is still the case that most of these are of a *post hoc* nature. They evaluate the economic implications of a system (usually its costs) after it has been established, usually when it has been in operation for a number of years and sometimes when it has finished.

These studies were undertaken for a variety of reasons. In some instances the agency funding a particular system required an analysis of its costs and a report of what had occurred. In other cases the studies have been more of an academic exercise with economists interested in exploring the cost implications of new methods of instruction. (Recent publications have attempted to summarise and synthesise the information available from a number of studies (see for example UNESCO, 1977 and Spain *et al.*, 1977).)

This interest in media systems is likely to continue in the future, not only because technological developments will provide new scope for media use in education but also because media will become increasingly attractive to educational administrators and fund-providers on cost grounds.

The argument is simply expressed, but it is at the core of the economists' interest in this area, and its implications and ramifications will be explored throughout this book. Education is traditionally a labour-intensive process with teachers' salaries often taking up to seventy-five per cent of total cost. Where media are used to supplement the teachers' role they do not affect this basic situation. Where, however, television or radio is used to replace the teacher there is a substitution of capital for labour. The problem with any labour cost is that it is always rising. In contrast improved technology leads to the reduction of unit capital costs. So even from a starting position in which labour is cheap and capital expensive the unit costs move in opposite directions – labour upwards and capital downwards. The point at which they intersect depends on many factors but in the long run the use of more capital (which largely means media) as a substitute for labour in education becomes increasingly attractive. Media use in education is, therefore, likely to become of greater rather than lesser interest in the future.

Focus of an economic study

The interest of economists in education developed in the fifties and sixties through its possible effect on economic growth. Kendrick (1961) and Denison (1962) attempted to isolate the element of economic growth which was not due to increases in physical capital and labour inputs. This was called the residual and was taken to measure technical progress or the increase in the quality of labour and capital. Whilst Abramovitz might have been nearer the mark in calling the residual 'the coefficient of ignorance', attempts were made to isolate the proportion of this residual due to improvements in education. These showed that the residual was responsible for about half the economic growth and that education might be responsible for about half of the residual. So improvements in educational provision might be responsible for 25 per cent of growth.

At a more down-to-earth level Harbison and Myers (1964) showed a positive correlation between school and higher education enrolment rates and Gross National Product (GNP) in 75 countries. Bowman and Anderson (1963) studied the link between literacy rates and GNP in 83 countries. They found 32 countries with very low literacy rates and very low GNP, 24 countries with very high literacy rates and a high GNP, with a number of others approaching a high literacy rate but still with a low GNP.

All these studies face a general problem of attributing causation. For example it may be the wealthier countries that can afford to put more resources into education and so the conclusion might be that GNP growth causes high literacy rates and not vice versa. Bowman and Anderson generally concluded that high literacy was a necessary but not a sufficient condition for growth.

One result of these studies on policy was that more resources were devoted to education. In advanced economies which had near-universal primary and secondary education the school-leaving age was raised but the main emphasis was on higher education. In the UK for example education as a percentage of gross national product rose from about three per cent in 1950 to over seven per cent by the end of the 1970s, and the number of students in higher education rose from 180 000 at the beginning of the 1960s, to over 500 000 some 15 years later. In developing economies, in contrast, the emphasis was much more on establishing universal primary and secondary education and enabling basic literacy and numeracy skills to be achieved. Here too, however, higher education was also substantially expanded.

One result of this large expansion of resources to education was an increasing focus on the internal efficiency of the education system. As the desire for expansion increasingly came up against either physical or financial constraints greater attention began to be paid to use of media. Not only might they enrich the quality of educational provision but they might also allow expansion to be achieved through greater efficiency.

In school education in advanced economies media are used mainly as an extra help to teachers rather than as a means of doing without them at all. Hence the term audio-visual *aids*. The reasons for this are partly practical and partly political. On the practical level, school pupils usually require supervision. So, whether the television screen is showing a programme, or the radio transmitting some information, or the computer allowing some individualised instruction, a teacher usually needs to be on hand to supervise, assist, or even just to make sure the students are paying attention to what is being said or shown.

In the school system the main role of educational media is to improve the *quality* of educational provision. It increases costs and whilst it might increase the quantity of output (say in terms of the number of pupils achieving a certain grade) its main function is to improve the quality through an enrichment of the educational process.

The political reason for media being used as a supplement to existing educational provision, rather than as a substitute in the school system, is the attitude of teachers. One of the major problems surrounding the successful introduction of media into an educational institution is the suspicion, if not downright hostility, of the instructors. There are all sorts of reasons why teachers view educational media suspiciously, but one of the most important is the fear that it may be doing them out of a job. This fear has a very real foundation.

With compulsory schooling from around 5 to 16 in most developed countries, the education market is to all intents and purposes saturated. Demand is virtually at its maximum possible level. There are two ways in which the school population might be increased: either through a natural growth in the child population or through government policy to extend compulsory schooling downwards to three years of age or upwards to (say) eighteen years of age. Both these changes, however, are unlikely to occur quickly and in the short term the pupil population is more or less fixed. The number of teachers is linked to the number of pupils through the pupil/teacher ratio. So in the short term the way to increase the demand for teachers is to reduce the pupil/teacher ratios, one of the reasons for the continuing pressure from teacher unions for smaller classes.

Now in a situation of virtually no growth in the pupil population, the use of educational media as a substitute for labour implies a worsening of the pupil/teacher ratio and teacher redundancies. It is no wonder that teachers view media suspiciously if their use could lead to the loss of jobs. So whenever media are presented to teachers, their role in supplementing and improving the quality of the teacher's own personal contribution is stressed. Even where media do take over the teaching role, as in some computer-assisted instruction in primary schools, other roles in the instructional programme are found for the teacher. The situation is different, however, in many developing countries where economic, geographical or teacher shortage problems often prevent children from obtaining access to secondary education. Here educational media have an important role to play particularly in overcoming teacher shortages and enabling children in remote areas to receive education. Where labour is the scarce resource, as is the case in these situations with skilled teachers, the substitution of capital for labour makes a great deal of sense. Thus a great deal of attention has been paid by international organisations such as the World Bank and UNESCO to the potentiality of educational media in developing countries and relevant studies will be referred to in later chapters.

Higher education provides in both developed and developing countries greater scope for labour substitution. On the practical level the students involved need far less supervision than their school counterparts. Indeed, conventional instruction in higher education occurs largely without supervision. On the political level also, problems are fewer. Higher education is a growth market. In the UK about fifteen per cent of the appropriate age group were in higher education in the mid-1970s. The demand for higher education, particularly at the subsidised price at which it is offered, is likely to continue to grow.

For this reason, higher education teachers have less cause to worry about the effects of teacher-substituting technology on the security of their employment. (This fact, however, has not made them any less suspicious of this technology than their school counterparts.) Indeed, it is when educational policy-makers have studied the pressure of demand in relation to the limitation of resources that they have turned to educational media. One of its major purposes in the expanding environment of higher education is to produce labour substitutions to allow for a larger student population for any given amount of resources, e.g. the use of closed-circuit television to extend the audience for a lecture.

Finally this study is concerned with systems of educational media rather than individual items. In Chapter 2 various types of media are discussed. Although the list given there is by no means comprehensive, it ranges from overhead projectors to television and computers. To try and report on the economic costs and benefits of each of these items would be a mammoth task. Moreover, in most cases, the question would not be a meaningful one. For example, the cost of an overhead projector could be readily obtained but how is one to evaluate its benefits in any quantitative sense? These items are usually used as aids to teachers rather than having a function of their own. The more sophisticated media produce the same problem. Even where television or computers are used to substitute for the teacher's role, they are rarely used on their own. Usually they form part of a system of media which might include audio-visual and written elements as well as some personal tuition elements. It is often preferable, therefore, to view educational media as applied through a system of instruction rather than a collection of individual components. Much of this study will be looking at the subject as a system. However, the general analytical approach, particularly in costs analysis, can also be applied to individual items such as television, radio and computers. (Whether and how they can be reflected in an economic study will be discussed in Chapter 4 on the benefits of educational media.)

So whilst there may be a variety of reasons for introducing media into an education system any media use will have economic implications. How far these economic implications should affect media decisions is a matter of judgment. It is possible, however, to establish a framework within which economic factors can be related to the achievement of objectives and it is the major task of this book to show how this might be done.

Scope and plan of the book

This book is primarily concerned with the role of economic analysis as an input to decisions on the use of educational media. It therefore surveys economic studies and past reports of media projects not so much to provide generalised conclusions on the use of media (although some are possible) but to illustrate how economic analysis of both costs and benefits can be useful to decision-makers. Its orientation is, therefore, to helping guide future decisions, and inquests of past decisions are included only in so far as they indicate lessons to be learned. This concern with decisions implies an emphasis on models and frameworks. Chapter 2 begins by discussing the range of media now available and their particular characteristics in an educational setting. It then seeks to establish a framework for choosing the appropriate media for a given educational task by establishing a relationship between educational objectives, learning tasks, learning stimuli and media. The point that is emphasised is that the choice of media comes at the end of the chain rather than at the beginning. It is not a question of looking at the machinery available and thinking what you can do with it, but of starting with the education objective to be achieved and establishing through the use of task and stimuli analysis the appropriate media for the job.

The heart of an economic analysis of educational media is the concern with efficiency, and Chapter 3 deals with the central questions of what 'efficiency' means when applied to education and how it might be measured. The application of efficiency concepts to education is defended and it is stressed that efficiency studies require a concern with both costs (inputs) and benefits (outputs) and their interrelationship. The chapter concentrates particularly on the objectives of educational systems, institutions and courses and how these might be translated into measures of output, and finishes with a discussion of how the efficiency of educational media might be evaluated.

Having established the theoretical framework in the opening chapters, the analysis now moves to a more detailed investigation of the specific components of an economic study: benefits and costs. Chapter 4 is concerned with benefits but does not attempt to provide a general survey of empirical studies. Instead it concentrates on the methods and problems involved in measuring the educational achievement of media systems, using empirical studies to illustrate the points being made. The subjects discussed include the need to specify objectives, including overcoming the problems of multiple objectives, the difficulties of measuring cognitive and non-cognitive achievements, and the wider implications of educational media systems, such as their effect on the distribution of income, status and power in a society.

Chapters 5 and 6 deal with the costs of media systems. In the first of the two chapters some simple cost concepts are introduced and brought together to show how costs analysis can provide insights into the costs structure of media systems. The costs differences between media and traditional systems of education are particularly emphasised. The second chapter deals with some of the problems inherent in costs analysis and show how these might be overcome. These problems include the identification and measurement of costs, the treatment of capital costs, and the calculation of an appropriate interest rate.

The analysis of benefits and costs in Chapters 4, 5 and 6, draws on examples of particular systems and projects to illustrate a point or argument. In Chapter 7 a more detailed study of a number of these projects is provided. The projects chosen represent different types of media and illustrate different forms of costs and effectiveness analysis. They are designed not just to provide information on the particular projects as representative of a particular use of media, but to highlight the different analytical and methodological approaches to the economic analysis of media. Amongst the projects which come under close scrutiny are the Open University in the UK, the Telesecundaria project in Mexico, the Nicaraguan Radio Mathematics Project, and the PLATO computer-assisted learning project in the USA.

Finally Chapter 8 draws together some of the main themes explored in the book. As a recurrent theme is the role of economic analysis in guiding decisions about media use in education, this final chapter discusses why many media innovations seem to fail and what is required to make such innovations more effective at the course, institutional and national level.

2 Media Choice

2.1 DIFFERENT FORMS OF MEDIA

A vast array of equipment of increasing sophistication is now available for educational use. This can be divided into four main areas of print, sound, vision and teaching machines, and Table 2.1 provides a list of some of the different forms of educational media under each heading. This is not a comprehensive list; indeed given the rapid changes in technology that are occurring, it cannot pretend to be. Its main purpose is to serve as an illustration of the range of media now available to educationists.

This classification concentrates on the means by which instruction is conveyed rather than the method of instruction itself. In McLuhan language it stresses the medium rather than the message. For example, the same intellectual approach is likely to be adopted in a piece of instruction that becomes embodied in a programmed text and a teaching machine. The first,

TABLE 2.1 Range of educational media

Print	*Sound*	*Vision*	*Teaching machines*
Books	Radio	Board and chalk	Teaching machines
Textbooks	One-way	Television	Computers
Programmed Texts	Two-way	Open-circuit	
Readers		Closed-circuit	
		Cable	
Journals	Radiovision	One-way	
		Two-way	
Pamphlets	Audiotape/cassette	Videotape	
Booklets	Gramophone records	Film	
		16 mm	
Offprints	Telephone	8 mm (± sound)	
		Filmstrip	
		Overhead transparencies	
		Slides (± sound)	

however, uses the printed text as the medium, whilst the second uses a machine. Therefore, they are classified separately.

Print

The printed word, of course, is one of the oldest means of communication. In the teaching process it allows a gifted teacher to reach a wider audience and a division of labour to occur within any given teaching institution. Thus the offerings of Paul Samuelson as a teacher of economics are not restricted solely to students able to attend the Massachusetts Institute of Technology. Equally, a teacher in any other university or college need not duplicate Samuelson but can concentrate on other aspects of the instructional process.

Books have (or had) the advantage of being reasonably cheap. They allow individual learning at a student's own pace and make it easy for the students to revise. A student can always go back over a page not understood. One disadvantage is that books are largely non-interactive. The author does not know the standard of the students before they start (although he can make some assumptions). More important, he has no way of knowing whether they are understanding the material he is putting over to them. Often textbooks are developmentally tested amongst fellow academics instead of amongst students. The former tend to judge a book by its style and its clarity in putting over something they already know. A better judgment of clarity would come from those who do not understand the content beforehand.

The programmed text is one method of introducing an interactive mode into the textbook form. This is based on the principles of programmed learning where a complex issue is broken down into small components. Each component is then studied and its objectives specified. As a result, the instructor is clear about what he expects the student to know when he has finished studying each particular component. A typical programmed text then proceeds by making a series of statements in which the student has to fill in key words or concepts or asking a series of questions to which the student has to reply. By indicating the correct responses and replies, the text enables the student to see whether he understands the material as he proceeds.

Reading of printed material is still the most common means of learning in higher education, certainly in the arts and social science fields. Ever since the invention of print, the book has made inroads into the traditional lecturing form of instruction. Some now believe, as does McLuhan, that the book itself is now under threat from the new forms of communication. The evidence, however, is that audio-visual instruction does not act as an alternative to the printed word but competes with it as a substitute for the traditional lecture. It is the face-to-face teacher/class situation which bears the major brunt of the attack from audio-visual technology. The book is still required and most examples of systems of educational media in use in higher education still rely heavily on the printed word. It is interesting to note that almost every contribution to the study of educational media (including this one) has used the printed word as its means of communication.

Radio

The simplest form of sound communication technology is one-way radio which is used to expand the audience for a piece of verbal instruction and also to allow students to hear this instruction without necessarily attending the place at which the instruction is given. It thus fulfils both an expansion and a convenience function. The disadvantages of simple one-way radio transmission are that it provides voice without vision, is non-interactive, and does not allow recall or revision by students. The last point is often a very important one in the learning process. A student who does not understand a page of instruction in a book can refer to it again. If he is studying something that assumes that he knows something else, he can refer back in the book to where the original subject-matter occurs. In a simple radio transmission, a student who misses a key point may be lost for the rest of the programme. Developments in the field of sound instruction have sought to overcome these handicaps of non-vision, non-interaction and non-revision.

In any form of structural instruction, radio is rarely used on its own. Usually, as with BBC further education broadcasts, radio is linked to the printed word with special booklets, pamphlets and increasingly fully illustrated texts being integrated with the sound material. This has developed in BBC broadcasts and now, with the Open University, into radiovision which attempts to provide a visual element in sound broadcasts. This takes the form of a printed text which might contain pictures, diagrams, tables and illustrations as well as the printed word. The radio programme is then used as a guide to the printed text. During the course of such a programme, the student would be referred at various points to the text, diagrams would be explained, pictures described and highlighted, and so on. One advantage of this approach is that it produces a quasi-television presentation at a fraction of the cost. Indeed, given the misuse of television that often occurs, radiovision is seen by many in educational broadcasting as a very cost-effective means of instruction.

The non-interactive handicap is overcome by two-way radio transmissions in which students can speak back to the lecturer. Sometimes this can occur whilst the speaker is actually speaking, but more often it takes place in the form of a question-and-answer session at the end of the talk. Another alternative is to link two-way audio systems to television to provide a comprehensive audio-visual system; this will be discussed later.

The problem of non-recall has been overcome through the use of audiotape and records. Audiotape is the more flexible. One method is for the student to tape the programme as it comes off the air and then use the tape at his own convenience. Alternatively, the air transmission can be dispensed with and the instruction taped directly. This can then be transmitted to students by post or carrier. The viability of this alternative depends on cost and will be looked at more closely in Chapter 7. The use of tapes or cassettes allows the student to play back material very conveniently and enables him to proceed at his own pace. Records are a little more inflexible. They cannot be taped off the air and the student cannot easily revise small segments of the material.

Finally, in the sound category of educational media, the telephone is rapidly being 'discovered' as an instructional aid. It is increasingly being used as a link between the at-a-distance student and his tutor. Colorado State University, for example, in their off-campus programme have a provision for a student to phone his tutor at a specified time after having watched a videotape (Baldwin *et al.*, 1972). The Open University is increasingly using the telephone as a major means of communication between student and tutor. Moreover, it is now using telephone tutorials in which a group of students are linked with a tutor simultaneously by telephone and carry on a tutorial discussion. As with other forms of educational technology, its practitioners have found that a technology used for one purpose requires special techniques and approaches when it is used for instructional purposes. A great deal of training and preparation by tutors is required in order for telephone tutorials to be used productively.

Video

Turning to visual forms of educational media, we must begin possibly with the oldest of all – the live lecture. Nowadays, however, even 'chalk and talk' has been affected (afflicted?) by the technological revolution. The traditional blackboard and white chalk finds itself under challenge from the whiteboard and coloured pencils. On a more sophisticated basis, various aids are now available to the lecturer to enable him to provide a greater variety of instructional modes. Examples of these are slides with or without sound, filmstrips and overhead transparencies through the use of a projector. Animated film is also available with or without sound, and thus can also be used as a substitute for the traditional method.

A more complex form of visual technology in education is television. It is important to distinguish television in its production role from television in its transmission role. Many universities have a television facility and use this mainly for production purposes. In other words, using television enables certain things to be done which could not be done by an individual lecturer in front of a class – or at least it allows them to be done better. Science students can follow the details of an experiment far better through television, rather than crowding round the lecturer. Medical students can follow an operation better on television screens rather than all crowding round a patient. More complex programmes can be prepared which introduce film and animations, of which a good example is 'Sesame Street' with its combination of visual images, animated cartoons, games and so on.

Television in its production role in higher education tends to act as an aid to the individual lecturer, allowing him to present his material in a different manner. The main function of television in its transmission role is to provide a larger or different audience. This transmission function is both conceptually and practically distinct from the production capabilities of television. The lecturer may wish to present his material in exactly the same way as if the cameras were not there. His reason for having television is not to do anything differently but to have a larger audience. The use of television, however, will produce certain constraints so that the lecturer is likely to behave and prepare his material differently than in a situation where the cameras were not present. However, he will not be using television for its production capabilities.

There are various ways in which television transmission can be used. Closed-circuit television allows something which is taking place in one area to be seen in a limited number of other areas close by. This is often used to allow lectures in one room to be seen by overflow audiences, or for instructional purposes for science and medical students as previously outlined. Most universities with a television facility have closed-circuit transmission.

A wider audience can be obtained through open-circuit transmission on particular channels. In the USA the Instructional Television Fixed Service (ITFS) allows certain channels to be used for educational purposes over a particular geographical range. In 1971 there were 65 such systems using 157 channels in different parts of the USA. In the UK an educational channel has not yet been agreed, and education broadcasts such as the Open University use national transmission facilities.

An alternative means of transmission is the cable system now becoming increasingly popular in the USA. Cable provides an alternative to transmission through the air. Its advantages are that it usually provides better reception and supplies dozens of channels instead of the restricted number available over the air. A disadvantage is that its geographical spread is limited (see Adler and Baer, 1973).

Whatever the exact form of transmission, most television is sent out at a particular point in time on a one-way system. This produces the problems of non-interaction and non-revision previously mentioned in the discussion of sound technology. The non-interaction problem is being overcome in a variety of ways. One method is to provide one-way vision and two-way sound. This means that students watching a television lecture live, in a variety of locations, can ask questions of the lecturer either during the lecture or afterwards. Students can see and hear the lecturer, but he can only hear them. Stanford University use this system in their MBA courses for off-campus students. Ideally, a two-way audio–video system is better in allowing the lecturer to see who is asking the question. This, however, is often prohibitively expensive and can only be used in limited circumstances. For example, City University New York have such a system for the closed-circuit television that links up a number of the individual colleges within the university.

However, these systems are only possible where the lecture is transmitted live. Often, only recordings are transmitted and here, of course, it is impossible to provide a two-way audio or visual system during the course of a lecture. One way round this is to have the staff member concerned available at the end of a telephone to answer questions after the lecture has finished, but this is not always satisfactory. The Open University uses a method where a tutor (not the original lecturer) is available either on the telephone or in a special study room, where students have watched a programme, to discuss it afterwards.

The major problem with television transmissions is that the student cannot control his learning situation. The programme is transmitted at a particular time and there is no way of playing back any material which has not been understood. One way of solving this problem is to use a videotape and to deliver the programme through other means than air or cable transmission. Colorado State University has an off-campus programme for post-graduate students that consists of videotaping lectures given to on-campus students and delivering the tapes by carrier van to various off-campus sites within 48 hours. Students view the tapes at these locations at a time convenient to them. Moreover Colorado try to deal with the interactive problem by arranging for the lecturer concerned to be available to deal with students' queries after they have viewed the tape.

One handicap with videotape is that it requires a special machine for viewing. The advantage of air or cable transmission is that programmes can be seen on a television set, which nearly everyone possesses. Videotape usually has to be seen at communal viewing centres, and this limits its flexibility. However, this can be overcome by setting up a library system in which students can come and view the tapes independently at their own convenience. Furthermore, advances in technology are reducing the cost of videotape machines. They are already being marketed for home use to record ordinary television programmes and the time may come when it is economically feasible for a video-recorder to be sold as part of an ordinary television set.

Teaching machines

Finally there are teaching machines. Whilst other forms of media were initially developed for commercial and entertainment reasons, and later adapted for educational use, teaching machines – as.their name implies – were developed specifically for educational purposes. They attempted to embody the understanding of the learning process developed by educational psychologists and technologists directly into a media form.

Computers are the most sophisticated development of the teaching machine. The hardware elements of a computer system of instruction consist essentially of the following: a central computer with its memory, input–output system, logic and data-processing functions; the terminal at which the student user interacts with the computer; and the communication system between the terminal and the computer.

Rapid developments in technology are improving the capacity of computer hardware systems. Innovations in microelectronics are increasing the memory capacities of computers in relation to their size, producing powerful microcomputers for commercial, general and educational use. Terminals are being linked not just to print-outs but visual display units on which questions, instructions and visual images can be shown, including a capacity for a student to present his own visual images. Communications alternatives include telephone or cable lines or, for geographically dispersed populations, the use of satellites. As with all educational media, however, hardware is of no value without appropriate software – the basic programs of instructions to be used by the computer. An important development here is the use of suitable computer language, by which tutors designing programs, and students using them, can communicate with the computer. One of the most interesting projects over the last decade and a half, which has produced developments in both hardware and software, is the PLATO project at the University of Illinois. It is described more fully, together with a costs analysis, in Chapter 7.

2.2. CHOICE OF EDUCATIONAL MEDIA

Knowing about the characteristics of the medium is not a sufficient basis for choosing the appropriate medium for a particular piece of instruction. The classification and description of the different types of educational media given in the previous section provide no guidance on which particular equipment would be most useful in a particular learning situation. For example, a decision may need to be made about the use of television in a medical course. Knowledge of the many different ways in which television may be used for educational purposes is of limited value. One needs to know what the course is trying to *achieve*, what students are expected to *learn* and which particular *stimuli* the instructor expects to be of value in the learning situation. All this can then be related to the different forms of media available.

In other words, choosing appropriate educational media should work forwards from the instructional needs of the particular subject concerned. The medium is the end point of the decision, not the starting point. Indeed, one of the major causes of the failure of educational media to realise their potential arises out of situations when they are used for their own sake or 'because they are there.'

A framework for more rational decision-making on the use of educational media must be devised, and this section suggests a conceptual approach or algorithm for such a choice. An appropriate model is to divide the decision into four vectors of objectives, tasks, stimuli and media as follows:

Objectives Analysis → *Task* Analysis → *Stimuli* Analysis → *Media* Analysis

This approach is based on those adopted by Wilbur Schramm (1973) and Michael Oatey (1972). Schramm identifies three vectors of task, media and cost. His third vector of cost is discussed in Chapters 5, 6 and 7 of this book, and is excluded here. Schramm's approach is to start with a given educational task and then identify the different types of media capable of performing this task. The next stage is to choose between these media on cost grounds. This is perfectly satisfactory if one can be sure that each medium will produce the same educational result. Oatey emphasises the need for a further vector between Schramm's 'task' and 'media'. This he refers to as 'content' and it involves the different types of learning stimuli appropriate to different media. The approach adopted here is to integrate Schramm and Oatey's classification to provide a comprehesive model of educational media choice. This chapter is concerned with the first element – relating educational content to educational media. Having chosen a group of media able to perform a given educational task it is then necessary to analyse the costs and benefits of each medium. This is discussed in subsequent chapters.

Objectives

There have been many attempts to set down educational objectives, and a comprehensive classification was provided by Banjamin Bloom and his associates at the University of Chicago (Bloom, 1956). These workers collected information on curriculum objectives and instructional material from a wide-ranging group of institutions together with data already existing in the literature. From all these sources they produced their own classification of educational objectives. Their first classification was into three domains. The cognitive domain referred to 'recall or recognition of knowledge and the development of intellectual abilities and skills'. The affective domain referred to 'objectives which describe changes in interest, attitudes and values', whilst the psychomotor domain referred to the area of 'manipulative or motor skills'.

Within the cognitive domain, Bloom divided objectives into six categories. These were:

1. Knowledge, which included knowledge of terminology, specific facts, conventions, classifications, criteria methodology, principles, theories and structures.
2. Comprehension, which included the skills of translating verbal into symbolic statements, interpretation and extrapolation.
3. Application, through the use of general ideas in particular situations.
4. Analysis, containing the skill of breaking down a statement into its constituent parts and including the analysis of elements, relationships and organisational principles.
5. Synthesis, being the reverse procedure of bringing together different elements to form a whole.
6. Evaluation, involving judgments about the value of material through the use of internal or external evidence or criteria.

Bloom's taxonomy is an abstract work in that it is intended to distil and categorise the existing literature and information on educational objectives from a variety of different subjects, courses and institutions. Since its publication the taxonomy has been analysed and criticised by many scholars. Some of these criticisms have arisen from the many attempts to apply the taxonomy to particular subjects.[1] For example, Duncan (1972) argues that the taxonomy is of limited use in the *formulation* of objectives. 'More important than classifying existing statements of objectives may be the question of what requirements should be met when formulating objectives in the first place.' Pring (1971) argues against the notion that objectives can be classified into a stage-by-stage process in the sense, for example, that knowledge must precede comprehension. In many cases knowledge involves comprehension and application.

On the question of behavioural objectives in general MacDonald-Ross (1973) has provided a critique which lists 16 objections. Of these he considers the following eight to be the most important:

1. No consistent view exists as to the origin of objectives, i.e. who sets them and what value-judgments are involved.
2. In the educational domain no well-defined prescriptions are available for deriving objectives, i.e. there is no agreed process whereby objectives are established.
3. Objectives do not prescribe the validity of test items, i.e. the objectives by themselves cannot specify the relevant tests to be used in evaluation.
4. The level of specificity problem has never been solved, i.e. there is no agreement on how detailed or specific objectives should be.
5. Weak prescriptions lead to costly feedback, i.e. the costs of designing learning systems which do not initially work well can be quite considerable.
6. Lists of behavioural objectives do not adequately represent the structure of knowledge, i.e. the listing of objectives misleads in the essentially complex structure and interrelation of ideas and knowledge.
7. The use of behavioural objectives implies a poverty-stricken model of student–teacher interaction, i.e. it limits the scope for changes through classroom interaction.
8. The behavioural objectives scheme suffers from many of the weaknesses of any operationalist dogma, i.e. for example the emphasis on short-term simple objectives rather than long-term more complex ideas.

Despite these criticisms the specification of behavioural objectives has stimulated the search for greater clarity in the presentation of learning objectives. In attempting to evaluate the effectiveness of the learning process it is necessary to be clear about what one is trying to achieve. This approach, and the developments and discussions it has provoked, is concerned with developing a greater understanding of the learning process.

However, even a faithful adherence to Bloom's philosophy does not provide much guidance on the use of media. For example, in the category of 'knowledge' an economics course may include as one of the objectives, knowledge of the law of diminishing returns. This may even be specified in more detail as 'the student should be able to show through the drawing of graphs that if one factor of production is fixed whilst the other is varied, as the number of variable factors is increased the return to the last factor of production employed diminishes'. This by itself provides little guidance to the instructor of that part of the course as to which form of educational medium (chalk-and-talk or television, for example) is most appropriate. It is the function of task analysis and stimuli analysis to fill this gap between educational objectives and educational media.

Tasks

Task analysis takes the given educational objectives and specifies the kinds of learning needed for their achievement. Gagné (1965) provides a useful taxonomy of learning tasks which is shown in Table 2.2 (Table 1 from Gagné (1965) pp. 63–4).

TABLE 2.2 Gagné's taxonomy of types of learning

Type 1	*Signal learning*. The individual learns to make a general, diffuse response to a signal. This is the classical conditioned response of Pavlov (1927).
Type 2	*Stimulus–response learning*. The learner acquires a precise response to a discriminated stimulus. What is learned is a connection (Thorndike, 1898), or a discriminated operant (Skinner, 1938), sometimes called an instrumental response (Kimble, 1961).
Type 3	*Chaining*. What is acquired is a chain of two or more stimulus–response connections. The conditions for such learning have been described by Skinner (1938) and others, notably Gilbert (1962).
Type 4	*Verbal association*. Verbal association is the learning of chains that are verbal. Basically, the conditions resemble those for other (motor) chains. However, the presence of language in the human being makes this a special type because internal links may be selected from the individual's previously learned repertoire of language (see Underwood, 1960).
Type 5	*Discrimination learning*. The individual learns to make different identifying responses to as many different stimuli, which may resemble each other in physical appearance to a greater or lesser degree. Although the learning of each stimulus–response connection is a simple Type 2 occurrence, the connections tend to interfere with each other's retention (Postman, 1961).
Type 6	*Concept learning*. The learner acquires a capability of making a common response to a class of stimuli that may differ from each other widely in physical appearance. He is able to make a response that identifies an entire class of objects or events (see Kendler, 1964). Other concepts are acquired by definition, and consequently have the formal characteristics of rules.

TABLE 2.2 *Continued*

Type 7	*Rule learning*. In simplest terms, a rule is a chain of two or more concepts. It functions to control behaviour in the manner suggested by a verbalized rule of the form, 'If *A*, then *B*', where *A* and *B* are previously learned concepts. However, it must be carefully distinguished from the mere verbal sequence, 'If *A*, then *B*', which, of course, may also be learned as Type 4.
Type 8	*Problem solving*. Problem solving is a kind of learning that requires the internal events usually called thinking. Two or more previously acquired rules are somehow combined to produce a new capability that can be shown to depend on a 'higher-order' rule.

Source: Gagné (1965) pp. 63–4.

Signal learning is a situation in which a learner is conditioned to react to a given signal. A dog which growls as strangers approach the front door is an example of this.

Stimulus–response learning requires something more precise from the learner. Here it is necessary for the learner to recognise a given stimulus, to be taught a response and to be reinforced after a response has been made. This is the learning process that occurs when animals are trained to perform certain acts in circuses, for example, or when young children are being socialised.

Chaining is the putting together of several stimulus–response connections. It requires knowledge not only of particular connections but also of the links between them so that a particular task can be accomplished. A good example of a motor chain is the tying of a knot where not only must specific connections be learnt but also their relationship to each other until a knot eventually occurs.

Verbal association is verbal chaining where the connections occur through the use of speech. The learning of a foreign language is an example of a verbal chain in which a specific foreign word might produce a response which can be linked with a word the learner already knows in her own language. Gagné uses the example of the French word 'alumette'. To convert this word into the English word 'match' requires the following connections and links between them in the student. First he must be able to say the French word. Then he must understand the English word. Already, therefore, he is involved with two stimulus–response connections. One of the ways a link between them might occur would be for the student to connect 'lum' of 'alumette' with the English word 'illuminate'. So the student may learn this word by linking a match which 'illuminates' to the foreign word 'alumette'.

Discrimination learning consists of being able to discriminate the correct response from a series of very similar responses. In the example above it requires distinguishing that alumette rather than alumine means match. It thus involves not only learning the chains but learning the difference between them. Another good example of discrimination learning is the ability to choose the right key for a lock or to distinguish geometrical shapes.

Concept learning involves learning to classify different stimuli. Concepts are used to group individual occurrences and to identify them. In this way the complexities of individual events in the real world are clarified. Thus the concept of 'profit' in accounting terms involves grouping all those instances in which revenue exceeds cost. The student must be able to distinguish 'profit' from 'loss' and this requires experience of different situations where profit and loss occur.

Rule learning is the relationship between two or more concepts such that if one concept holds then the other does or does not follow. This involves learning the concepts and relating them to each other. For example, if marginal revenue exceeds marginal cost, profit can be increased by increasing output. This is rule learning involving four concepts in which if two concepts hold the third can be achieved by acting on the fourth. Schramm points out that 'to learn to state the rule is not always to "understand" it fully', a sentiment with which many first-year economics students will concur in relation to the marginal optimisation rule given above!

Problem solving is the most complex form of learning, requiring the task of combining various rules to solve a new problem. It can be applied to simple tasks like catching a train or to more complex problems like Keynesian employment theory. It would be simpler to give an example from the train problem rather than unemployment problems. In this case the problem may be to arrive at a destination at a given time. A number of rules are available to help solve this problem. For example, I may have learnt the rule that it takes 30 minutes to reach my destination from my home station. This rule in turn arises from solving a problem and depends upon rules about speed and distances. Another relevant rule is the time taken from my home to the departing station and this rule too will arise from rules about walking speeds and distances. Thus, beginning with concepts such as speed and distance and relating these to produce rules, I can combine these rules to provide a solution to a particular problem.

These types of learning are hierarchical or cumulative in that each step depends on knowledge of the previous one. Thus rule learning depended on understanding the concepts on which these rules were based. In turn, understanding concepts such as speed and distance involves being able to understand other concepts such as miles and yards. This requires the ability to discriminate between different types of distances and so on.

While each learning task requires an understanding of a previous one, this is not to say that all tasks are required in each learning situation. Motor and verbal chains are needed for foreign-language teaching, but not necessarily in a course in history. Infant and primary-school teaching probably involves all the learning tasks at some time or other whilst secondary, further and higher education is likely to concentrate on concept learning, rule learning and problem solving.

This aspect of task analysis takes us a little further in relating objectives of instruction to the media of instruction. It enables content to be specified in terms of the particular learning tasks required of the student. Thus the law of diminishing returns previously referred to is a rule-learning task which involves knowledge of concepts such as factors of production, fixed, variable, marginal and returns. However, all this does is to specify in more detail what is necessary to understand the law of diminishing returns. It amplifies Bloom's taxonomy but provides no golden rule such as 'rule learning is likely to be more effectively taught through television'.

In fact task analysis involves a second component. It consists not only of the learning tasks for the student but the teaching tasks for instructor. As Schramm (1973, p. 27) puts it, what is required is a listing of the 'events of instruction'. He defines these events as 'what actually appears on the television screen or constitutes the teacher's classroom behaviour when trying to teach to a given objective'. Schramm quotes Gagné's list of instructional events as typical of many provided for this purpose. Gagné (1965, p. 304) gives nine events as follows:

1. *Gaining and controlling attention*. An external stimulus arouses the appropriate attentional set.
2. *Informing the learner of expected outcomes*. Communication, usually verbal, tells the learner about the kind of performance he will be able to do after he has learned.
3. *Stimulating recall of relevant prerequisite capabilities*. The learner is

reminded of the relevant intellectual skills, and also verbal knowledge that he has previously learned.

4. *Presenting the stimuli inherent to the learning task*. The particular stimuli to which the newly learned performance will be directed are displayed.
5. *Offering guidance for learning*. Usually by verbal communications, the learner's thinking is directed by prompts or hints until the essential performance is achieved.
6. *Providing feedback*. The learner is informed of the correctness of his newly attained performance.
7. *Appraising performance*. Opportunity is provided for the learner to verify his achievement in one or more situations.
8. *Making provisions for transferability*. Additional examples are used to establish increased generalisability of the newly acquired behaviour.
9. *Insuring retention*. Provisions are also made for practice and use of the new capability so that it will be remembered.

Gagné's nine 'events' in effect provide a timetable of presentation by which a particular task might be learned by the student. It gives the instructor guidance on how to approach the organisation of his teaching. Equipped with his objectives, and his task analysis of both student's learning tasks and instructor's teaching tasks, he will be able to organise the content and sequence of presentation of his instruction.

Stimuli

This content must now be linked to the various media options available. The next stage is stimuli analysis. This in effect takes the fourth of Gagné's learning events, the various learning stimuli, and breaks them down into their component parts. In other words, 'the particular stimuli to which the newly learned performance will be directed' are listed in detail.

Oatey (1972) provides a list of stimuli which include:

visual motion
visual skills
visual variety
colour
verbal visual stimuli
verbal aural stimuli
tactile stimuli
problems

examples
written responses
aural responses
motor responses
constructed responses
multiple-choice responses.

This list is by no means exhaustive but is designed to illustrate some of the stimuli which an instructor might choose to direct the learning of his students. In principle, each stimulus can be related to one or more types of educational medium. In fact, it is possible to construct a matrix in which each stimulus is linked to the appropriate medium, and this is shown in Table 2.3. It will be readily seen that this table is not an exhaustive matrix of all stimuli/media combinations. Indeed, it is possible to argue about whether some of the asterisks are in the right places. However, its main purpose is to illustrate a conceptual approach to the relationship between learning stimuli and educational media. It shows, for example, that computer-assisted learning – at least in its most advanced form of the PLATO project – is capable of providing most of the learning stimuli and that chalk and board, for all its traditional approach, is also fairly comprehensive. From the stimuli point of view, teaching through problems and examples seems possible with any form of media, whilst written responses are only available from a limited number.

What has been presented so far is a conceptual framework within which an appropriate form of media might be chosen. We have produced a model linking educational objectives to content to learning stimuli to media. This model, and the various tables and matrix involved, is useful in showing the range of options available to the instructor and the way in which a logical approach to decision-making might be established. It is essentially a self-designed model for any instructor. In other words, in approaching a learning situation, the instructor should set down his own objectives for the material, choose the learning tasks he expects from his students, formulate his own learning tasks through the use of Gagné's 'events', list the appropriate stimuli which he wishes to use and with the aid of the matrix see which forms of media are useful for the stimuli he has chosen.

However, this still leaves him with a range of options. Consider the example of the law of diminishing returns mentioned earlier. The objective may be that the student should be able to state the law and show graphically the effect on output of increasing the employment of one factor of production with the other factor fixed. This involves the tasks of concept and rule learning. In choosing the stimuli required for this purpose, the instructor

TABLE 2.3 Educational media and learning stimuli

									Television								
	Text-books	*Pro-grammed texts*	*One-way radio*	*Two-way radio*	*Radio-vision*	*Audio-tape*	*Tele-phone*	*Board and chalk*	*One-way*	*Two-way*	*Video-tape*	*Film*	*Film with sound*	*Slides*	*Trans-paren-cies*	*Teach-ing ma-chines*	*Com-puters*
Visual motion								•	•	•	•	•	•			•	•
Visual skills	•	•			•				•	•	•	•	•	•	•	•	•
Visual variety									•	•	•	•	•	•	•		•
Colour	•	•			•			•	•	•	•	•	•	•	•		•
Verbal visual					•			•	•	•	•	•	•	•	•		•
Verbal aural			•	•	•	•	•	•	•	•	•		•	•	•		•
Tackle								•									•
Problems	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Examples	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Written responses		•						•								•	•
Aural responses				•	•		•	•		•							
Motor responses		•		•	•			•		•	•					•	•
Constructed responses								•									
Multiple-chain responses		•						•		•	•					•	•

may decide that as the student needs to show his understanding graphically he will need to use visual motion, colour, verbal visual, verbal aural, examples, written responses, aural responses and possible multiple-choice responses stimuli.

The matrix in Table 2.3 will tell him which media can provide these stimuli. Clearly radio is out because of the need for visual motion, and this also rules out radiovision although it covers almost all the other stimuli. Two-way television is very effective although it makes a written response very difficult. If this was needed, the television facility would have to be combined with some classroom or personal tuition. In fact, only computer-assisted instruction (CAI) and board and chalk covers all the stimuli needs. As far as CAI is concerned, this requires an ultra-sophisticated system such as PLATO. Many CAI systems would not be able to produce this range of stimuli; so possibly, only board and chalk on its own can do the job. This example indicates the limitations of such an analysis. First, of course, it only discusses each form of medium in isolation. If two different types of media were combined, they might provide a more comprehensive range of stimuli than one on its own. More important, however, the matrix tells us nothing about the *quality* of the stimuli provided. Board and chalk may be able to provide all the stimuli needed to teach the law of diminishing returns but television, whilst not providing all the stimuli, uses them more effectively. So the matrix is only the starting point for guiding decisions on the use of educational media.

Learning effectiveness and educational media

What is required is some evaluation of the effectiveness of particular types of media in teaching particular learning skills. Schramm (1973) points out that there have been 'very few attempts to synthesize the expected usefulness of different media in relationship to different learning tasks'. One such attempt was by W. H. Allen who produced a matrix relating particular learning tasks to different types of media. This matrix is reproduced in Table 2.4. It will be seen that Allen used three categories of high, medium and low to reflect the relative effectiveness of particular types of technology in helping to achieve certain learning tasks. These categories were based on Allen's professional judgment rather than the accumulated evidence of research studies because as Schramm pointed out, very little research has, in fact, been carried out in this area. Allen's categorisation is essentially a subjective qualitative assessment, and those with different experiences of the use of educational media are likely to disagree with it. For example, he judges that printed textbooks, audio recordings and oral presentation do not rate a 'high'

Table 2.4 Allen's chart of instructional media in relationship to learning objectives

Instructional media type	*Learning factual information*	*Learning visual identifications*	*Learning principles, concepts and rules*	*Learning procedures*	*Performing skilled perceptual-motor acts*	*Developing desirable attitudes, opinions and motivations*
Still pictures	Medium	HIGH	Medium	Medium	Low	Low
Motion pictures	Medium	HIGH	HIGH	HIGH	Medium	Medium
Television	Medium	Medium	HIGH	Medium	Low	Medium
Three-dimensional objects	Low	HIGH	Low	Low	Low	Low
Audio recordings	Medium	Low	Low	Medium	Low	Medium
Programmed instruction	Medium	Medium	Medium	HIGH	Low	Medium
Demonstration	Low	Medium	Low	HIGH	Medium	Medium
Printed textbooks	Medium	Low	Medium	Medium	Low	Medium
Oral presentation	Medium	Low	Medium	Medium	Low	Medium

Source: Allen (1967) W. H. 'Media stimulus & types of learning. *Audio-Visual Instruction* 2:1, 27–31.

category for any learning task, and that there is no medium which rates a 'high' category for learning factual information, performing skilled perceptual motor acts and developing desirable attitudes, opinions and motivations. It is a little difficult to see why printed texts should rate a 'low' category for learning visual identifications whilst still pictures should be given a 'high' category.

Schramm points out that the large majority of Allen's categories are in the 'medium' range, particularly if one omits the psychomotor area. He therefore concludes that 'most school tasks can be performed by a number of different media, and in most cases, quite satisfactory . . .'. In other words, this level of sophistication may not be necessary for practical decisions about which media to use. Within a broad range, they can do most tasks more or less equally well. If one excludes some obvious absurdities, such as using audio material for visual identification, this may be a fair conclusion.

However, the purpose of this section is not to provide a ready reference guide to the choice of educational media. Such decisions are more likely to need individual judgment from those concerned rather than be taken by reference to some programmed recipe book. Our main purpose here is to indicate a conceptual approach to such decisions. The essential lesson is that a decision on educational media must be related to educational content and the model outlined here is a method of ensuring a systematic approach to such a decision.

Reasons for media use

An economic study is obviously likely to focus on the role of educational media in providing education more efficiently. It must be remembered, however, that media can be used to achieve other objectives. Some of these have economic consequences, but many others produce an educational benefit which cannot be quantified in economic terms. It might be best to begin by distinguishing between media being used to expand facilities for students who could obtain education by conventional instruction and those for whom it provides a new opportunity. The object of the first category is simply a cost-saving exercise in which, for example, lectures given to one group of students are transmitted via closed-circuit television to further groups of students in other locations.

In the second category, a number of examples come to mind. In higher education, media may be used to provide an opportunity for part-time off-campus education to those who otherwise would have no other opportunity for higher education. This is particularly relevant to vocational and recurrent education. For example, at Colorado State University, the

SURGE project allows students at various industrial locations in Colorado to participate in graduate engineering and business courses on a part-time basis. This is done through a videotape and correspondence system. If the project did not exist most of the students would be prevented from taking the courses either full-time because of their employment difficulties or part-time because of the geographical distance between their place of employment and the university campus. Stanford University provide a similar service to employees of various business firms in the San Francisco area, although in this case the courses are transmitted through a television channel rather than by videotape cassettes.

Perhaps the most comprehensive and sophisticated approach to the use of educational media to widen the access to higher education has come from the Open University. Here a combination of correspondence, television, radio and personal tutorial elements are used to allow students on a nationwide basis to receive undergraduate, graduate and post-experience education. If the Open University did not exist, its students would not simply enter the conventional universities. Most of them would lose the opportunity of any form of higher education. Therefore, in the role of meeting the extra demand for higher education, educational media provide not only an alternative route, but for many students the only route, through the system.

Educational media widen opportunities in a number of other ways. By allowing individualised instruction they enable slow learners to proceed at their own pace. A system of programmed learning, for example, can incorporate far more flexibility through the branch programmes for particular difficulties than a teacher has the time to afford when dealing with a whole class. A videotape can be played back by students, if a point has not been understood, far more easily than asking a live lecturer to repeat himself.

It is the flexibility that arises from throwing off the burden of the timetable that provides many of the educational benefits of using media. If lectures are recorded on cassettes, students and lecturer no longer have to turn up at a particular time and place for the educational experience to occur. Instead, the student can view the cassette at his own convenience, replaying the tape as and when necessary. If a particular piece of instruction can be put on a computer, the student can use the terminal for his hour's worth of material whenever it suits him.

Media can be used to provide not only instruction but also counselling and guidance. The TIPS project at the University of Wisconsin (Kelley, 1968) uses the computer to provide each student with a periodic self-assessment of his knowledge. At each stage the computer gives the student information on his present performance and, on the basis of this and his past performances, provides him with guidance on the next stage of his study and which of the many instructional avenues provided by the university he ought to go along. For example, he may be recommended to study a particular chapter of a book, attend a lecture or tutorial, or seek specialised remedial work from his tutor. At the same time the tutor is kept informed of the progress of each of his students and can see how all students performed on each part of the course. The TIPS project is an example of computer-managed instruction (CMI) as opposed to computer-assisted instruction (CAI) which provides instruction itself rather than guidance.

Educational media can be used to provide access to higher education for physically handicapped students. Tuition at home is possible, through the use of correspondence materials, video and audio cassettes, and this helps to overcome the problems for physically handicapped students in conventional institutions which arise from their lack of geographical mobility. More specific handicaps, such as blindness and deafness, can also be accommodated by adaptation of the learning materials. The Open University has a number of blind students, and has organised special facilities for deaf students.

In schools education this concern to provide access for pupils handicapped not only physically but geographically, economically or socially, is emphasised. For example in Mexico the Telesecundaria project is designed to extend secondary education to the rural areas by providing television programmes linked to workbooks which can be seen by small groups of pupils in isolated areas. An analysis of Telesecundaria is given in Chapter 7.

Perhaps the most fascinating aspect of the potential of education media lies in its implications for the role of the teacher. In a conventional system of instruction the teacher performs a number of different roles, all of which require specific skills. He designs the course and sets out its objectives; he prepares the learning materials, particularly the lectures, himself; he delivers the lectures and may also provide the tutorial facilities; he provides guidance and counselling to students, related to the particular course, to academic studies in general and also to personal problems; and he will probably assess the students' work both during the course and in the final examination. This is probably something of a caricature if applied to one lecturer on one particular course. In many universities and colleges, courses (and certainly degree programmes) are now designed by a group of academics and no one person is likely to be involved in all the activities mentioned above on one particular course. However, the lecturer is still likely to be involved in all of them at some time or another. He may help to design a particular course and give some of the lectures on it, he may provide tutorials for another course, guidance to students on personal matters, and help examine a further course. The main point is that he is expected to have a range of skills appropriate to the function of a teacher in an educational institution. Clearly, each individual will have his strengths and weaknesses and can not be expected to excell in them all. For example, the role of providing the knowledge which students are meant to acquire has long been delegated to another source, the textbook.

Given that knowledge and learning are not equally distributed amongst teachers, the theory of the textbook is that those with specialised skills and knowledge in a particular field should invest a proportion of their time and (other people's) money in setting down this knowledge for a wider audience. This is one aspect of the specialisation of teaching skills which media help to facilitate. (Although the cynic may be reminded of the alternative explanation for textbooks, namely 'He who can does, he who cannot teaches, he who cannot teach carries out research and he who fails in all of these, writes textbooks' (Blaug, 1970).)

This specialisation applies with even more force to other areas of educational media. Part of it arises out of the needs of the media itself. Radio and television developed a system which separated out the functions of the producer, director, writer and actor. (Leaving aside the technicians, cameraman, lighting, sound and transmission staff.) Consequently, the application of media to education has seen the development of a clash between the traditional autonomous all-purpose skills of the conventional teacher and the dependent specialised teamwork skills of communication technology. The teacher using educational media finds himself interacting with a far larger group of people than previously, many of whom have their own professional values and equal status in the teaching operation. This is another reason for the wariness with which teachers approach educational media. Even if it does not put them out of a job, it challenges their traditional autonomy in the classroom.

But the real question is whether the traditional system is the correct one. Should we expect teachers to acquire all these different skills, and would the educational process be improved if greater specialisation amongst the teaching staff occurred? Of course this specialisation could occur without educational media. Even with conventional modes of instruction certain staff could specialise (though perhaps not exclusively) in the design of material; other staff, who might be better in delivery, could specialise in lecturing. Staff who are better in an interactive situation could look after tutorials, and so on.

The point about educational media is that they make it easier for this specialisation to occur. The Open University, for example, already operates such a system. It distinguishes between those who design and write the course material (the central academics) and those who provide personal tutorial services, counselling and guidance (the regional academics). Within these two broad groupings there is further specialisation. Some central academics will play little part in the design of a particular course but will write the material to fit the design and objectives of their colleagues. Often outside academics will also be used to fulfil this role. On the radio and television components of a course the academic may design and write the script. He may also take part, but equally others both inside and outside the university will take part; of course the television director, who is a non-academic, also plays a crucial part in the operation. Within the regional academic staff there is sometimes a distinction between staff employed to provide personal and general academic guidance and staff employed to provide guidance and tutorials on a particular course. Many people in education see this potentiality for greater specialisation in the teaching function, and greater individuality and flexibility in the student's approach to the learning situation as the major benefits of using educational media.

3 Efficiency in Education

3.1 INTRODUCTION

Will the use of media enable education to be provided more efficiently? This is the central question of any economic analysis of media use in education. In turn, however, it raises a more fundamental question of what is meant by the word 'efficiency' when it is applied to education.

In economics the concept has two different meanings. External efficiency is concerned with the interrelationship of the different components that go to make up a complete economic system. Such a system is said to be efficient when it achieves with a given set of resources the pattern of production and allocation of goods and services which best meets the wishes of consumers. As in a market economy such allocation is primarily determined by relative prices, the analysis of external economic efficiency is much concerned with the principles of price determination.

Internal efficiency, on the other hand, is concerned with the behaviour of the individual components of the system. More specifically it is concerned with the process by which a production unit such as a factory converts inputs into outputs. For example, a tyre factory will use various inputs such as men, machines and rubber as a raw material. Through a knowledge of rubber technology it will convert these various inputs into the output of a motor car tyre. This tyre might be bought by the consumer as a spare of replacement or it may itself be used as an input in another production process such as motor car production.

Internal efficiency measures the success of this transformation of inputs into outputs and it is this meaning of efficiency which can best be applied to the education system. In asking whether the use of media enables education to be provided more efficiently we are analysing the extent to which this media use changes the relationship between education inputs and outputs.

An industrial example

In defining internal efficiency a distinction must be made between technical efficiency and economic efficiency. The first refers to a relationship between physical inputs and outputs (e.g. in the case of car production a relationship between so many men, machines and materials on the one side and finished cars on the other). The second attaches monetary values to the inputs and so enables the relationship between inputs and outputs to be expressed in terms of costs per unit of output. It is this second approach, that of internal *economic* efficiency, which is of most value in the educational context.

An industrial example might be the best way of providing a more detailed explanation of the distinction between technical and economic efficiency. In the car industry for example there may be a number of firms using different combinations of men, machinery and materials to produce cars. To simplify matters let us assume that they can be divided into two categories of labour-intensive and capital-intensive. Now the most technically efficient firm can be defined in one of two ways. It is either the firm which produces the highest output for a given combination of inputs, or alternatively the firm which produces a given output with the lowest possible combination of inputs.

With this definition it would be possible to say which was the most technically efficient labour-intensive firm and which was the most technically efficient capital-intensive firm. But the two types of firm could not be compared because they use such completely different combinations of inputs. It is possible to say, for, example that a firm which produces a car in a given period with 4 men and 1 machine is more technically efficient than a firm that produces the same car in the same period with 5 men and 1 machine. But how does one compare the first firm with another that produces a similar car with 2 men and 2 machines? A comparison between physical outputs (1 car) and physical inputs (4 men and 1 machine or 2 men and 2 machines) cannot be made; unless, that is, one assigns monetary values to the men and machines and thus provides a common measuring rod.

This is what the measure of economic efficiency seeks to do. Supposing 2 factories each produce 100 identical cars per week. The cars use the same materials so that the only difference between the factories is the combination of men and machines. The factory with the more labour-intensive process uses 1000 men and 100 machines; the one with the capital-intensive process 200 men and 200 machines. The only way of comparing the efficiency of the two factories is to look at the relative costs of men and machinery. Table 3.1 shows the results of two different assumptions. In the first example wages cost £60 per week for both factories, but the factory with the more capital-intensive machinery pays £250 per week per machine whilst the other pays £100 per week per machine. As a result the capital-intensive factory is more efficient, producing a given output (1 car) with inputs costing £620 compared to £700 for the other factory.

Table 3.1 Economic efficiency under different assumptions

	Example I		*Example II*	
	Men	*Machines*	*Men*	*Machines*
Factory A				
Number	1 000	100	1 000	100
Cost per input per week	£60	£100	£60	£125
Total cost per input	£60 000	£10 000	£60 000	£12 500
Total cost	£70 000		£72 500	
Output per week (cars)	100		100	
Cost per car	£700		£725	
	Men	*Machines*	*Men*	*Machines*
Factory B				
Number	200	200	200	200
Cost per input per week	£60	£250	£60	£312.5
Total cost per input	£12 000	£50 000	£12 000	£62 500
Total cost	£62 000		£74 500	
Output per week (cars)	100		100	
Cost per car	£620		£745	

In the second example it is assumed that capital costs rise by 25 per cent whilst labour costs stay the same.[1] The result is that the labour-intensive factory now becomes the more efficient, producing a car for £725 compared to £745 for the capital-intensive process. As far as economic efficiency is concerned the relative prices of inputs are an important consideration.

3.2 EFFICIENCY AND EDUCATION

Now, what has all this to do with educational media?

Well, education can also be viewed as a production process. It too uses labour and capital to work on raw materials or semi-finished products and transforms them into finished output. In the school, teachers combine with buildings and equipment to work on the raw material of children and their minds and transform these into a finished product. This finished product might be measured at the school-leaving age and may then leave for the market-place of employment. Or it might be used like the tyre as an input into another part of the education production process – namely advanced school education. This process produces a finished product at (say) 18 which as before can enter the market-place of employment or be used as a semi-finished product in yet another part of the education system, namely higher education. Undergraduates enter higher education with a given level of knowledge and are transformed through higher education into final graduates. The illustration can be continued with these graduates either entering the employment market or being used as inputs in the post-graduate education production process.

Essentially the internal economic efficiency of educational institutions measures this process of using inputs to produce outputs, and media become important because they change the input mix. Whether one is adding media to the teachers already there, or substituting media for teachers, the relationship between inputs and outputs will change.

Is education like industry?

This analogy between education and industrial production has been attacked by many people closely involved with education. Some find the whole notion of discussing education in monetary terms or placing a monetary value on the results of education distasteful. 'Education is about children, not money.' Care needs to be taken in evaluating such statements, for they cover a range of different attitudes to the subject, each of differing validity.

One argument frequently heard is that the pleasure to be derived from teaching and learning cannot be measured in any quantitative terms. How does one measure, for example, the pleasure derived from seeing the joy on a child's face when knowledge dawns? Now this is a valid point. Its analogy in the industrial situation is the pleasure the worker gets out of the job he is doing. Mass-assembly-line production of motor cars is clearly more economically efficient than the painstaking craftsman's job of an individual assembling a car on his own. Yet the latter is more likely to give the worker much greater satisfaction. So it can be argued that in terms of producing a given package of knowledge there may be more efficient methods but these may eliminate any pleasure that both teachers and students obtain from the learning process.

This is a complex area but there need not in principle be any conflict between efficiency and job satisfaction. Essentially efficiency measures the extent to which an institution, firm, etc. achieves its objectives. In industry the objective is assumed to be the maximisation of profits or at least the minimisation of costs. In this situation it is therefore appropriate to measure efficiency by the lowest cost per unit of output.

Education is, of course, more complex and the system is usually attempting to achieve a multiplicity of objectives often not very well articulated and sometimes in conflict with each other. This is one of the factors that makes efficiency measurements in education more difficult. However, if the job satisfaction of teachers was considered to be an important objective of the system some means of measuring this satisfaction would have to be found and its achievement included in any efficiency measure.

This multiplicity of objectives creates problems on the output side. Instead of the simplicity of the car factory's objectives there tends to be a confusion of different objectives in education. These will be discussed at greater length later in this chapter. However, the view still seems to be held that whatever objectives education is attempting to achieve it should achieve them at minimum possible cost.

A second objection to the education–industry analogy is the argument that the nature of the production process is not known to the same degree in education as in industry. Industrial technologists can forecast with a great degree of accuracy what the result will be if inputs and materials are combined in a certain way. Education technologists cannot be so sure. Do large classes or small classes produce better learning results? Does one reading scheme produce faster learning than another? Do students learn more quickly from lecture-based or tutorial-based teaching systems? There are few generalised answers to these and many other questions about the teaching–learning process in education. How then can we measure the relationship between outputs and inputs from different education processes when we cannot be sure of the nature of the input–output relationship in these different processes? If we cannot be precise about the way in which children learn, how can we be sure that the fact that small classes led to better exam results than large classes had anything to do with the fact that classes were small or large, rather than some other external factor? If a media-based system of instruction leads to better performance by pupils to what extent is this the result of the use of media?

This is a fair point which introduces a necessary word of caution, but it is hardly new. Education research is engaged in a continuous investigation into the teaching–learning relationship. Whilst it may be true to say that the output–input gap of a particular institution, system or technology may not be due directly to the efficiency of that institution, system or technology, but may be due to external factors, this does not mean that we should abandon attempts to measure the input–output gap but rather that we should intensify efforts to identify, relate and measure these external factors.

These problems are well known to economists and other social science researchers. In seeking explanations for social and economic phenomena and attempting to explain social and economic behaviour, they are confronted by a myriad of possible explanations. Conceptually this is dealt with by trying to isolate the effect of each variable independently while keeping the others constant, and statistically the technique of multiple regression analysis has been well developed to cope with this problem.

A third type of objection is based on the practical difficulties of actually measuring inputs and outputs. This highlights two fundamental differences between efficiency analysis in industry and education. In industry inputs and outputs are easily identified and there is general agreement on the appropriate measurement either in physical or monetary terms. Thus a motor car factory can identify the various inputs that go into the making of a motor car. Its physical output is the car itself and this is then valued in monetary terms by what the consumer will pay for the car. Even if the factory is producing a range of models it is possible to measure the output of each model and identify the inputs that relate to this output.

In the education system, things are not so easy. What is the output of the school system, for example? Is it simply external examinations success which is capable of some form of measurement, or a particular standard of reading and numerical ability at a particular age? Most educationists, whilst accepting these measures of output, would also stress other outputs of the school system less capable of quantification, such as the installation of common cultural values, the fostering of team spirit, consideration for others, respect for authority, and so on. How can these outputs be measured and related to particular inputs? A school may use a certain amount of resources to achieve great examination success but at the same time exhibits a great deal of tension, bad pupil–teacher relations and so on. Another school with the same resources has less examination success but there is a harmonious friendly atmosphere and it is more likely to send well-adjusted children into the outside world. Which school is the more efficient?

This argument takes us back to the previous one about the multiplicity of objectives for the education system. However the objection here is not that one ought not to mix economic and human values, but that even if one specifies objectives clearly one cannot measure them in practice. Certainly it is wise to be circumspect in attempting a comprehensive efficiency analysis of educational institutions that includes all objectives. Nevertheless it is possible to make some progress in this direction especially in relation to those objectives which apply to the use of educational media.

3.3 EFFICIENCY IN HIGHER EDUCATION

Higher education is a particularly interesting case because its inputs and outputs have been much discussed by economists. In fact most attention has been given to outputs, and pursuing the industrial analogy Carter (1965) has stated that 'A university is a multi-product firm with three main classes of product'. These are:

1. Men and women with degrees;
2. Research;
3. Storage of knowledge and maintenance of cultural standards.

Others have defined the objectives slightly differently, for example dividing the third objective into separate functions of information storage and the fostering of civilisation; but there is general agreement about the broad headings given by Carter. The difficulties arise in specifying the outputs in more detail, suggesting ways in which they might be measured, and relating specific outputs to specific inputs.

Teaching output of higher education

The first type of output of universities[2] mentioned above, namely the production of men and women with degrees, relates to the teaching functions of higher education institutions and at first sight seems clear. As mentioned earlier, students arrive in a semi-finished form, they are worked on through the tuition process and emerge eventually as graduates. One difficulty is that there is no uniform graduate. They can be differentiated by class of degree – ordinary, honours, first, second or third class – by subject and by level, first degree and post-graduate for example. The teaching output of a university is as varied as the different models coming off a car assembly line.

This in itself is not a problem. The real difficulty arises in trying to measure the value of this variety of output. How do we determine the value of a university education and degree, and how can we distinguish between say an arts degree and a science degree or a degree from Leicester University and one from Liverpool University?

Higher education and earnings

One answer is to take the extra income obtained by graduates over non-graduates over their lifetime as an indication of the monetary value of a degree. Thus if a sample of arts graduates from Leicester University earned more over their lifetime than non-graduates, this would give a measure of the value of their degree to them. Moreover, if they earned more than Liverpool University arts graduates, this might indicate a higher value to the output of Leicester arts faculty than Liverpool arts faculty.

However the whole of the earnings differential between graduates and non-graduates is not attributed to the different education experiences of the two groups. It is argued that clearly graduates have a measure of innate ability and intelligence which would give them an earnings differential over other groups whether they went to university or not. This has to be allowed for in measuring the specific value of university education. As a result some ratio, usually two-thirds, of the earnings differential is taken as the particular contribution of higher education, but there is very little empirical basis for any precision on this matter.

The exercise can be taken further by relating the value of lifetime's earnings differentials, suitably amended and discounted to the investment in inputs that produced the output. The net earnings differentials are then expressed as a rate of return on the original investment. Thus, calculations on the rate of return to individuals from a first degree in the UK range from 20 per cent (Ziderman, 1973) to 8.5 per cent (Blaug, 1967). These rates of return are analogous with rates calculated on industrial investments which relate net earnings to the cost of the investment.

Whether these rates of return are a measure of efficiency is another matter. In the industry example, doubt focuses on whether the prices at which outputs are valued reflect competitive market prices. A monopoly firm which can raise prices as it wishes, and might thus earn a rate of return of 30 or 40 per cent, may in fact be less efficient in its operation than a firm operating in a competitive environment in which it cannot easily raise prices and which earns 10–15 per cent.

The question of the valuation of the output is raised in even more acute form in the case of higher education. What are we measuring when we take the earnings of graduates as the value of their degree? One school of thought argues that the earnings actually measure the extra contribution of graduates to the output of the economy as a result of their higher education experience. Thus a doctor's earnings reflect the skills and qualifications which his years of training and education have given him, and these earnings are an accurate reflection of the value of his degree. The same argument can be applied to other areas of vocational education but it often comes under attack when non-vocational higher education is discussed. What particular skills has 3 years of English Literature given the arts graduate and how are these skills reflected in the job he may be doing? Well, in some jobs, such as journalism or librarianship, the skills are more easily identified but in general management and administration they may be a little more difficult to specify.

In this case it is it is usually argued that the higher education experience has provided the graduate with general skills which give him an advantage over non-graduates. Thus, for example:

> In so far as higher education leads to a more rapid appreciation of a situation, faster learning times, greater ability to solve problems, a capacity for analysis and abstraction and an ability to work without detailed supervision, employers may become more willing to consider graduates (Department of Employment, 1974).

The argument here is that it is not the particular skills of a specialised area of study which determine the value of a degree but the general skills which the higher education experience provides.

So it is argued that the teaching output of higher education is reflected in skills of varying kinds which are valued through the earnings of graduates. But do earnings reflect the relative skills of graduates? In the industrial situation it was pointed out that the earnings of different outputs might simply reflect their differing monopoly power. In education a similar position may arise although here the power lies with the buyer of educational output rather than the seller. In the UK over 50 per cent of graduates work in occupations where salaries are negotiated in one form or other with the government. These include the civil service, education, medicine and most research establishments. Even where government is not involved in fixing salary levels, the occupations themselves are often organised to act like the industrial monopolist. Thus, lawyers and accountants restrict output by limiting the number of entrants into their professions and are thus enabled to earn relatively high incomes as a result of the excess demand for their services. Perhaps the situation which most closely approximates to the market model is the entry of scientists and technologists to work in industry where presumably the firm is forced by market forces to take a commercial view of the value of graduates. It is significant that many of the studies of the relationship between education, earnings and employment concentrate on scientists, engineers and other technologists. Even here, however, there are many doubts. Mace and Wilkinson, 1977, for example, have shown that employers of graduate engineers rarely take market forces into account in fixing salaries.

Another attack made on the earnings approach is the argument that higher education is valued in the employment market not for any particular skills but as a screening device. It saves employers from spending a great deal of time, effort and money in deciding which of their applicants is going to make a useful contribution to the leadership and management of the firm. This argument applies more particularly to non-vocational graduates and is the corollary at the higher education end of examinations to the argument often heard about the value of school-leaving examinations to employers.

In fact the screening mechanism operates at both the admission and examination ends of the higher education spectrum. At the examinations end, it is argued that employers see the piece of paper waved by the graduate as an indication of general intellectual ability and hard work. The graduate has no particular skills that will be of immediate use to the firm. The final examination of the university simply acts as a proxy for the entrance examination of the firm. This argument is similar in form to the earlier one which stressed the general skills which higher education is likely to give a student. In this case, however, it is argued that the employer is interested in the piece of paper in its own right rather than the skills, even of a general nature, that this piece of paper represents.

However, it is difficult to accept this argument too readily. Many employers who take on arts and general degree graduates with little specialised skills relating to their future employment do not rely solely on the evidence of their degree results to assess their suitability for future employment. Employers frequently hold entrance examinations or other screening devices of their own, the most common of which is the civil service entrance examinations.

The admissions variant of the screening concept is compatible with this evidence. In this case it is argued that higher education has little other function than choosing the most able people in a particular age group. The educational experiences it subjects these people to is of little relevance, and the *reductio ad absurdum* of this argument is that the most useful task for higher education institutions in this context would be to choose the people they would have admitted and then send these people out into employment. Usually, however, the admissions and examinations functions of higher education are combined to provide a view, as Arrow states, on which it

> contributes in no way to superior economic performance; it increases neither cognition nor socialization. Instead, higher education serves as a screening device, in that it sorts out individuals of differing abilities, thereby conveying information to the purchasers of labour (Arrow, 1974).

This view has been criticised by Layard and Psacharopoulous (1974); they postulate a number of phenomena that might be expected to occur if the screening hypothesis was correct, and then produce evidence to the contrary.

This brief survey of the debate about how the teaching output of higher education might be measured gives some indication of the nature of the exchanges between economists on this subject. There are clearly severe difficulties in using earnings as an indicator of the value of output. This has led others to turn away from the earnings approach and to try to find some other measure of output.

One approach is to use an educational measure of output by concentrating on a sub-system within the higher education system as a whole and even within an individual institution of higher education. By concentrating on the inputs and outputs of a particular course of study a more accurate measure of efficiency might be obtained.

Cognitive skill measurement

One of the major teaching purposes of higher education is to impart some cognitive skills, and the attainment of these skills is usually tested at the end of a course. However, examinations generally test the level of knowledge of students at the end of a course without necessarily relating this to what they might have known at the beginning of the course. The true measure of the educational output of an institution is not the general level of knowledge and attainment of students when they leave the institution but the difference between this 'exit' level and their level on entering the institution. Thus it is argued in the school context that a school which takes in a high-ability intake and achieves a high level of public examination successes in five years' time may in fact be less educationally efficient than a school which takes in a lower-ability intake and achieves less examination success. The final standard of knowledge of the students without reference to their initial standards is an unreliable guide to the educational output of an institution.

The practical problem is to find an objective measure of initial and final knowledge, which can be used for comparative purposes between a number of different courses and institutions. In the USA tests of this nature do exist, particularly in mathematics.

In the UK a particularly interesting example is the test of economics comprehension developed by the Economics Education Project (EEP) at Heriot Watt University (see Scott, 1974; Attiyeh and Lumsden, 1971, 1972) Pre- and post-tests consisting of multiple-choice objective questions were designed and developmentally tested. These were then given to all first-year economics students at UK universities and a measure of the learning gain or output in terms of the change in percentage scores in each institution obtained.

This approach also meets with a number of difficulties which need to be overcome. The EEP was not an efficiency exercise in that it did not relate the measure of output to any estimate of the cost of inputs in the different institutions. Indeed, it would be difficult to do so because they are measured in different units. Inputs would be costed in money terms whilst outputs would be measured in terms of learning gain. However, in principle a comparison is possible. Suppose there are two universities. University X spends £5000 on teaching 35 students economics. The learning gain shows an increase in the average percentage score from 30 per cent to 55 per cent correct. University Z on the other hand, spends £10 000 on teaching 60 students economics and the results show an increase in learning gain from 45 per cent to 60 per cent. Which university is more efficient in teaching economics?

In terms of learning gain, Z shows a better final score but taking into account initial standards of applicants, X has a larger learning gain of 25 per cent to 15 per cent. But how is this to be related to cost? The cost figures show a total cost and a total number of students. Dividing one by the other provides an average cost per student of teaching the particular course. In the case of university X, the average cost comes to £200 per student, whereas in the case of university Z, the cost is £167 per student. How does one trade off costs per student against learning gain? Is X or Z more efficient in teaching students economics?

By dividing average cost per student by the percentage learning gain, we obtain an average cost for each learning gain point. Thus, in the case of university X the cost is £8 per percentage learning gain (200 ÷ 25 per cent) and in the case of university Z the cost is £11.1 per percentage learning gain (£167 ÷ 15 per cent).

To what extent is this a meaningful measure? In one sense it is very meaningful because we are measuring precisely the relationship between inputs (costs) and outputs (learning gain). The answer has been phrased in exactly the same way as the costs and outputs of an industrial process would be formulated. In the industrial analogy the answer would tell us that each nut or bolt costs £8 in one factory and £11.1 in another. In this case, the answer is that each percentage learning point costs us these amounts in two different educational institutions.

But the figures also hide a great deal more than they tell. The problems on the output side will be dealt with later in the chapter, but economists will be more familiar with the problems on the cost side. The first difficulty is the average nature of the cost figures. University X has an average cost per student of £200 as a result of spending £5000 on teaching 25 students. An economist would want to know whether this was the optimum number that could be taught, or in other words at what point on its average cost curve the university is operating. Of particular importance is the marginal or extra cost of adding a few more students to the class. Suppose that it was quite possible to add another five students to the class with minimum extra charge to the teaching cost.[3] This would bring the average cost per student down to virtually the same amount as in university Z. In studying costs figures a distinction must be made between potential and actual data. This is particularly important in looking at the costs of educational media, as will be seen later.

However, it is important also to study the effect of changes in costs on the output side. In the example given in the previous paragraph, the effect of adding an extra five students to the class may mean a reduction in the overall learning gain, possibly for example because the teacher can no longer give as much individual attention to each student. Consider university Z. On the costs side, it is in fact cheaper than university Y because although its total costs are double, it takes in more than twice as many students. There seem to be economies of scale. Yet in the final analysis, Z is less efficient than Y because its students show such a poor learning gain. Are these two factors related? Is the poor learning gain a result of trying to teach too many students or reducing the personal attention each student gets and so on? So the costs data must be investigated to look at marginal as well as average costs and the effect of changing student numbers on output as well as costs. The figures also indicate the importance of 'learning gain' as a measure of output. Using the normally accepted measure Z seems more efficient than Y. It has lower average costs and higher *final* exam results. If learning gain is used, however, it becomes the less efficient university.

A number of futher problems arise on the output side. The first of these is the actual method used of measuring learning gain. In some areas, such as mathematics, it is possible to specify very precisely the knowledge and skills which will result from a piece of instruction and to devise tests that will measure these skills objectively. In other areas, particularly the arts, it becomes much more difficult. Economics is perhaps midway between the maths and arts examples. The EEP question paper, for example, required a great deal of work and developmental testing before it was considered suitable.

Another difficulty arises in ensuring that a test used for comparative purposes in different institutions is in fact fair to all concerned. For this to happen all the courses being considered must have the same objectives, otherwise in some of the institutions the test will examine what the designers of the test want to know and not the knowledge that the particular courses were designed to impart. The EEP exercise tried to overcome this by agreeing a basic core of economics knowledge which any student of a first-year course would be expected to know. The courses themselves might teach more than the text covered but the latter was the minimum or lowest common denominator of all courses that could be tested. In a strict sense therefore the EEP exercise is not a completely accurate measure of the efficiency of different economics courses. Those courses which perform comparatively poorly by the EEP criteria might be able to claim that they had other objectives which the EEP exercise was not designed to test. Notwithstanding these criticisms the EEP exercise is the most highly developed, sophisticated and used measure of comparative learning gain in the principles of economics that exist in the UK.

However, the major problem with the output side is whether learning gain, even if accurately measured, reflects the teaching efficiencies of different courses. Can it be argued that different learning gains in different courses or institutions reflects different teaching efficiencies? The problem is the one that was met earlier, namely that there may be all sorts of other factors affecting the learning gain besides efficiency. For example, the student in a particular institution may have a higher intelligence quotient (IQ) than those in another. Their actual knowledge of (say) economics may be no different than other students at the beginning of the course but their higher intelligence allows them to learn at a faster rate and to a greater depth. This may be reflected in a higher learning gain at the end of the course which may have nothing to do with the efficiency with which they have been taught.

Students' previous educational experience may help them to achieve a higher learning gain. For example, students who have learnt some mathematics may be expected to grasp certain economic principles rather more quickly than others. This prior knowledge of mathematics may not help them in the pre-test as they will have no economic principles to which to relate it, but it may have an effect on the post-test. Here again the higher learning gain will have nothing to do with the efficiency of the teaching system.

The principles of multiple regression analysis can be used to cope with this problem. Each of the important variables likely to affect learning gain (e.g. prior knowledge, innate intelligence, previous subjects chosen, etc.) is identified and its effect separately measured. With a large enough sample it is possible to separate out the effects of other influences and get a more accurate measure of the learning gain due to efficient teaching. Indeed if the sample is large enough other variables, such as size of teaching groups, can be introduced which will enable the effect of teaching methods on learning gain to be more accurately assessed.[4]

Other outputs of higher education

So far so good. Despite all the detailed problems it is possible to obtain a practical measurement of the teaching output of universities either at the macro end, by taking earnings of graduates as a reflection of their increased contribution to output, or at the micro end, by measuring the learning gain obtained from particular courses. Media in education are used almost exclusively for teaching. An economic evaluation of media therefore need be concerned only with the teaching outputs of an institution. However, teaching is not all that universities do. As mentioned earlier, they also function as a place of research, as a store of information and as a catalyst of civilisation. It might be useful to say a little about how these functions might be measured even though they are less relevant to a media analysis. The difficulty in this area lies in trying to find some quantitative measure of these functions.

It would be generally agreed that what Bullock (1975) has called 'the whole range of science and scholarship, organizing and making accessible existing knowledge as well as discovering and incorporating new' is an important, indeed an indispensable, part of a university's output. Attempts have been made[5] to quantify the research output of universities by, for example, taking the number of papers or words written as an index of output. This is clearly unsatisfactory as it makes no allowance for quality. A quality index can be partially established by grading the journals in which articles appear so that 5000 words in one journal carries more weight than 5000 words in another. Even if this were reasonably accurate, it does not allow for the nature of different papers in the same journal. One paper may have taken a great deal of time and thought, involve complex arguments and make a new contribution to knowledge in a particular area. Another paper may take up the same amount of words, yet have little originality and have involved much less effort. Someone has to make a subjective judgment as to the relative worth of the two papers. Even this case may not be the complete picture because there need not necessarily be a connection between time, effort and final result. The paper that makes an original contribution may have involved little research time, and conversely the paper that contains little originality may still have involved a greater amount of work.

The same principles that were applied to evaluating teaching output cannot be applied to research output. There is no market-place in which research output is bought and sold and therefore earnings cannot act as a proxy for output. There is also no objective test for evaluating different outputs to enable a 'research gain' equivalent of 'learning gain' to be evaluated.

There is no general answer to this question. At one end of the spectrum there are brave attempts to measure research output through the quantity of material produced, whilst at the other end there is the view that it is impossible to make any quantification and that the value of research output is best decided by the value-judgments of members of the researchers' peer groups. In between these opposing views is the practical attitude that the value of research output should be measured by the value of research input. In other words, if £5 million is spent on research, then this is the value of research expenditure and hence the value of research output. For certain purposes, such as accounting and budgeting, this is the only approach possible but it does not help to produce an objective measure of the value of research output.

All that has been said about research applies with even more strength to the information storage and civilising function of universities. The input valuation method can be used to assess information storage by taking expenditure on libraries as a proxy but there is no way that the civilising influences of universities can be quantified or indeed rigorously defined. Indeed this claim to be a repository of civilisation is very useful to universities because as Johnson (1974) has pointed out:

> it provides justification on both sides for the support of universities by both private and public subscriptions of resources, regardless of efficiency considerations, so long as universities behave as they are traditionally expected to do and as most other universities do. In this respect, support of universities is like adherence to a religion or church in that the pay-off from so doing is incalculable and problematical, but it is wise to buy insurance against unknown risks.

The difficulties of finding a reliable quantitative measure of the research, information storage and civilising influences of universities make it impossible to devise an accurate index of total university output. However, all is not lost for exercises in efficiency are usually done for comparative purposes. In other words, if we are seeking to compare the efficiencies of different institutions, for example, it may be possible to make some assumptions about the unquantifiable outputs that will allow us to concentrate on those items which can be quantified. For example in looking at two universities it may be possible to assume that the research, information storage, and civilising influences of the two institutions are about the same and therefore take the differences in teaching output as a proxy for differences in total output of the two institutions. If this is felt to be too much of a leap of faith, an alternative is to concentrate on the teaching output to establish the differences that exist there. It is then possible to state what the differences in the value of the other outputs would need to be in order to wipe out the difference in teaching output. This would then be left to the value-judgments of informed opinions. For example, it might be assumed that the total output of a university is split 50–50 between teaching and other outputs. If two universities are compared and one is found (by whatever method) to have a ten per cent higher teaching output, it would be necessary for the other to claim that its research and other outputs compensated for this by being at least ten per cent higher than the first university.

Indeed, it is usual for only the teaching output of universities to be quantitatively measured leaving it to reader's judgment as to what allowance should be made for other outputs. However, this creates another problem because outputs are only useful in efficiency analysis if they are related to inputs. If it were possible to measure all outputs, then it would be relatively simple to calculate all inputs and measure one against the other. However, if research outputs are not to be measured and only the efficiency of teaching outputs is to be calculated, care must be taken to include only those inputs that are related to teaching output.

This is not as easy as it may sound. It is a long-standing claim of those working in universities that research and teaching feed upon each other. As Carter has put it, 'like mutton and wool they are joint products of the academic sheep' (Carter, 1965). If this is true, then it is difficult to identify which inputs are being spent on teaching and which on research. If a teacher is involved in research activities, is it fair to allocate all his salary costs as teaching costs? One way around this is to allocate a certain proportion of his salary to research based on the proportion of his total time that is spent on research. This is by no means satisfactory as teaching and research feed back on each other. A tutorial session with a bright group of students might give the teacher a new insight into some research, whilst the results of some research activity may be fed straight into a lecture or tutorial. However, if the feedback is the same more or less in either direction, then deducting part of the salary costs, in proportion to the time spent, may result in a fair reflection of the inputs devoted to teaching. The same can be done with other inputs such as buildings for example.

It can be seen that the search for measures of efficiency in higher education, either of the system as a whole, of different institutions within the system, or simply of particular courses within an institution is an arduous and complex one. Indeed the view may be held that all these problems make the exercise a waste of time. This is not so for two main reasons. First, the terms 'efficiency' and 'inefficiency' are used in education and particularly higher education without a great deal of thought. Too often cheapness and efficiency are confused. As we saw in the earlier example university Z was cheaper but not necessarily more efficient. An awareness of the complexities of efficiency concepts may make people a little more wary about using them. Secondly, efficiency concepts are used implicitly to make resource-allocating decisions at present in higher education. It might help to make these decisions better if the manner in which the efficiency of educational institutions could be established was better understood. As far as media are concerned efficiency measurement, whilst still difficult, is less extreme because attention can be focused on the inputs of the media system and the teaching output that results. The other functions of higher education can generally be ignored.[6]

3.4 EFFICIENCY IN SHOOL EDUCATION

Much of what has been argued above in relation to higher education applies equally to school education. The model of a raw material or semi-finished product being transformed through the use of various inputs into another semi-finished or finished product still applies. Schools like higher education institutions also have a multiplicity of outputs. One important difference exists, however. Whilst universities have outputs which do not relate to their teaching objective and their work with students, school output is almost wholly related to what they achieve through their pupils.[7]

Thus in higher education the research, civilisation, and information storage objectives previously discussed refer to the contribution of staff and other inputs to areas not related to teaching students. These objectives alone might justify the existence of higher education institutions even if they took no students. Schools however exist because pupils exist. The complexity in the outputs of the school system arises not in distinguishing between teaching and non-teaching outputs as in higher education but in specifying precisely the different and varied components of the teaching output alone.

Cognitive measurement in schools

More particularly a distinction can be made between the cognitive and non-cognitive outputs of schools. As far as congnitive outputs are concerned the methodology of measuring such outputs discussed in the higher education section above applies here also. One major difference is the ability to relate any test scores to the contribution of the institution. This is difficult enough in higher education but at least in that context it is usually argued that it is influences on the student before he enters the institution, such as previous educational experience, which are important and these can be isolated and measured. In school education on the other hand it is argued that factors outside the school whilst the pupil is there – particularly home, family and neighbourhood background – are important influences on children's performance at school. In his exhaustive study of the research on inequality in education and society generally Christopher Jencks concluded that 'variations in what children learn in school depend largely on variations in what they bring to school and not in variations in what schools offer them' (Jencks, 1972). These conclusions are confirmed by another major study of international research in this area which states:

> When we examine the results across studies we find that school resources are not consistently important. The particular resources that seem to be significant in our study do not prove to be significant in other studies that include the same resources in the analysis.
>
> Background factors, on the other hand, are always important. In study after study a student's background has a strong influence on his educational outcomes.
>
> Furthermore the results are consistent across studies. The socio-economic status of a student's family – his parents' income, education and occupation – invariably prove to be significant predictors of his educational outcome (Simmons, 1974).

So in school education differences in cognitive skills as measured by standardised test scores are more likely to have been influenced by the intelligence, educational background and income of parents, home life, choice of friends, and so on than by variations in inputs at school. The implication of these findings is not that school has no effect on pupils' score attainments, for as Simmons points out 'we have little knowledge of what student outcomes would be were students not to attend school at all . . .' (op. cit.). Rather, it is that there is no consistent evidence on the effect of variations in school inputs on school outputs.

Non-cognitive outputs

There is, of course, more to schools than passing examinations or making gains in learning measured in some other way. These non-cognitive outputs of socialisation provide greater scope for disagreement. It might be generally accepted that schools should stress values such as honesty, justice, tolerance, and concern for others. But there is far less agreement on what is required for successful social living. Some would argue that in order to survive when they grow up children need to be instilled with the desire to achieve, the motivation to succeed, the willingness to compete and so on. Others would argue that the ability to work with others and to co-operate are the most important pieces of social equipment. Some might require children to be taught respect for authority and the ability to obey orders, while others might alternatively wish to encourage questioning criticism. As mentioned previously efficiency is related to objectives and it is not possible to compare the relative efficiencies of institutions with different objectives.

In addition the measurement and contribution problems related to non-cognitive outputs are probably more difficult than for cognitive outputs. Certainly attitudes and values are more likely to be determined outside the school than within it.

3.5 EDUCATIONAL MEDIA AND EFFICIENCY

The media are an input into the educational process. Efficiency is about the relationship between inputs and outputs, with inputs being measured by costs and outputs by benefits. So the economic analysis of media is concerned with the differences of costs and benefits between media systems and conventional instructional systems and between different types of media within a media system. Ideally any evaluation would cover all inputs and outputs of the system, and as far as media systems are concerned these involve teaching inputs and outputs only.[8] An ideal study of this nature would require a large population of students divided into different groups. Each group would be taught a given course by different teaching methods. These would include different types of conventional instruction such as large lectures and smaller tutorial groups as well as the different forms of educational media such as closed-circuit television, videotapes or open-circuit television for long-distance teaching, computer learning systems and others. Students would be tested at the beginning and end of the course and their learning gain measured. Allowance would be made for other variables that might have affected learning gain (e.g. previous educational experience) and a learning gain due to different media established. This would then be related to the different costs of various media and a cost per point of learning gain established as outlined earlier.

Unfortunately, we do not live in an ideal research world and experiments of this nature do not as yet exist. Most evaluations of educational media either study the benefits with only a perfunctory look at costs or concentrate on costs with little or no attention paid to benefits. Where both costs and benefits are brought into the calculation, this is usually in the context of studying a single system and is rarely applied to a comparative study of different types of media. Indeed, this lack of a comparative approach is one of the biggest problems to overcome in evaluating the effects of educational media. Too often papers consist of reports from practitioners of the results of their own particular experiments without any reference to the relationship between these results and the results of other experiments. It is impossible to make any objective assessment of the benefit of a particular system of teaching even if one is told that the test scores achieved were of a particular level unless one is given both pre- and post-test scores and also knows what test scores were achieved using alternative teaching strategies and the nature of the student population in each sample.

Studies which emphasise benefits without considering costs are understandable in one context. Many experiments with educational media are undertaken to widen educational opportunity. They are not introduced to produce an alternative to what already exists but to provide a facility that was previously absent. Any benefit therefore justifies the experiment, it is argued, because there is no alternative to compare that benefit with. For example, take a television and correspondence based course which caters for physically handicapped students. If this particular teaching medium was not introduced, these students would have no alternative. The decision to make available this facility, it is therefore argued, can only be based on the value-judgments of the decision-makers as to the importance of this kind of opportunity. Costs enter into the decision-making process in so far as there is a limited amount of money to spend and there will be competing alternative uses such as, for example, a remedial teaching unit for on-campus students. A decision between these two uses must be based on the judgment of the decision-makers as to their relative importance. The fine tuning of comparative cost–benefit analysis is not appropriate in this case.

This is a little disingenuous. It is true that a decision between a remedial unit for on-campus students and the introduction of a facility for off-campus handicapped students cannot be decided by comparing learning gains of the two different facilities. Unless we have a weighting system which can relate the benefits of one facility to the benefits of the other, this is not possible. In any event, any weighting system will be based on value-judgments. However, once a decision to provide facilities for off-campus students has been taken the costs and benefits of different methods of providing this facility can be compared. Thus for example the costs and learning gains of television and correspondence can be compared with those for a system which uses only correspondence. So education media systems which aim to widen educational opportunity still require an evaluation of their costs and benefits.

Many cost–benefit and cost analyses of education media turn into cost-effectiveness studies. This refers to a situation where the output or objective of a particular project is given and the costs of different methods of achieving the objective are studied. The one with the cheapest cost is ranked as the most cost-effective method.

Just as some educational media studies concentrate on benefits to the exclusion of costs, there are others whose main emphasis is on costs with little attention to benefits. These latter studies sometimes make some reference to comparative test scores of conventionally taught and experimentally taught students but this is usually not central to the argument. In effect the studies are assuming that the outputs, benefits or learning gains of students using the new technology will be at least equal to those of students using conventional instruction. They therefore concentrate on the comparative costs of the various alternatives. A variant of this is to argue that the benefits of media use will be greater than conventional instruction and to concentrate on showing how the costs of the new medium will be at least the same.

3.6 CONCLUSIONS

It has been argued that the efficiency concept which lies at the heart of any economic analysis of media is more elusive than might at first have been imagined. To identify any particular system as more efficient than another a comparison has to be made between their respective costs and benefits. The latter in particular pose major problems of identification and measurement. However many of these can be overcome and studies restricted to measuring teaching inputs and outputs are in principle possible.

Ideally comparative costs and benefits should be related in a single study. Most reports of particular projects, however, have either emphasised benefits, assuming costs of different systems to be at least equal, or emphasised costs, assuming benefits to be at least equal. Some of these studies are discussed in Chapter 7 as examples of costs and benefit analysis. But first the analytical approach itself must be explained.

4 Measuring Educational Achievement

4.1. INTRODUCTION

If this chapter was designed simply to summarise the large volume of empirical material evaluating the benefits of educational media it could be very brief. Indeed it might consist of one simple sentence which in one form or another appears in most surveys of this nature, namely to quote Wells (1976, p. 270): 'there are no significant differences (on cognitive measures of student learning) among a variety of technologies and instructional methods'.

In some respects this is a very useful statement. It crystallises the results of a large number of studies.[1] It is simple and easy to remember and it is very helpful in allowing costs studies to proceed on the assumption that the lowest cost alternative will also be the most cost-effective alternative. For if there is no significant difference in relation to benefits then costs become the most important criterion in choosing between alternative projects and media of instruction.

In most other respects, however, the statement is not very helpful. In most literature reviews the aggregate view of 'no significant differences' is arrived at by balancing those studies which concluded in favour of the new media against those which favoured the conventional media. It is also in part a reflection of the view that the differences in media were not the most significant factors in benefit differences or, as Chu and Schramm (1967) put it, 'Given favourable conditions, pupils can learn from any instructional media now available'.

The value of the generalised statement is also weakened by the fact that the studies which it attempts to summarise invariably use many different evaluation models and criteria and have been conducted at different standards of scientific rigour. Comparison between studies in order to achieve an accurate summary becomes very difficult.

This chapter therefore does not attempt to provide a general survey of empirical studies. As previously indicated, many such surveys already exist and their results are readily summarised in the 'no significant differences' conclusion. Instead, here we concentrate on the methods and problems involved in measuring the educational achievement of media systems using empirical studies to illustrate the points being made. Later in the book a number of projects are looked at in closer detail on both the costs and effectiveness side.

4.2 SPECIFYING OBJECTIVES

A survey of benefit studies of educational media indicates that most adopt a narrow cognitive approach – namely performance on test scores of one sort or the other. There is nothing wrong with this provided that it is generally accepted that this criterion is the major objective of introducing the system.

However, in some cases measurable cognitive improvement may not be the primary or initial objective. A media system may be introduced, for example, to increase participation rates or to try to improve the access to education for certain groups. Once access has been obtained and the system is in operation the cognitive scores of the participants might not be as high as those continuing to attend the traditional system. But it is unfair to judge the media system on that basis alone. If its primary aim was to increase access then that objective has been achieved. Whatever the level of the test scores in relation to those achieved through the traditional system, they are still higher than would have been achieved if the media system had not been introduced.

So any measurement of benefit must be related to objectives. This seemingly simple proposition is, however, often difficult to put into practice. In some cases the objectives of establishing the media system are not explicitly stated and sometimes cannot even be implied from the actual operation of the system. Where objectives are more explicit or can be deduced from behaviour they are sometimes vague or more often multidimensional. Thus a system may be introduced to increase access, reduce drop-out, achieve various cognitive objectives and also, particularly at the school level, inculcate various attitudes to society.

The Open University in the UK, for example, is clearly intended to provide university-level higher education. The original White Paper (HMSO, 1966) stated that 'It must be made clear that there can be no question of offering to students a makeshift project inferior in quality to other universities' and this is enshrined in the charter of the university, which is little different from that of other universities in the UK. Thus at one level the benefits of the Open University can be evaluated by general comparisons of the academic standards of the graduates in relation to those of other universities, or more specifically through the use of cognitive tests of the type discussed in Chapter 3. Even here, however, there are some difficulties because university education includes research as well as teaching and a general comparison would have to allow for both. Wagner (1972 and 1977) discusses this problem in relation to comparisons between the Open University and other universities in the UK and suggests ways in which the comparison can be a standardised one. This involves allowing for the different research proportions in the output of the two institutions by using the amount of staff time devoted to research.

However, the Open University is not just about providing higher education of a similar standard to other institutions. To whom the education is provided is also important. The Planning Committee report makes this clear when it states that the objects of the Open University should be 'to provide opportunities, at both undergraduate and post-graduate level, of higher education to all those who for any reason have been or are being excluded from achieving their aims through an existing institution of higher education' (HMSO, 1969). This objective was reiterated by the first Chancellor of the University, Lord Crowther, in his inaugural address:

> The first and most urgent task before us is to cater for the many thousands of people fully capable of higher education, who, for one reason or another, do not get it, or do not get as much of it as they can turn to advantage, or as they discover, sometimes too late, that they need (Open University, 1971).

Now clearly these two objectives are not incompatible but an assessment of the benefits of the Open University cannot be limited to what it achieves academically but must also include an evaluation of the numbers and types of students it attracts. Such an assessment has been made for the first-year intake of students by McIntosh *et al.* (1976). However, even this is not sufficiently comprehensive because the Open University charter also requires it to promote the educational well-being of the community generally. At one level this might be covered by the extent to which the general public has access to the learning materials through buying the correspondence text or through eavesdropping on the broadcast material which is transmitted on open BBC networks. More positively, the Open University has established a continuing education division specifically in relation to this objective. Clearly the Open University is a multifaceted institution and simple measures of its benefits are likely to prove inadequate in an overall evaluation of its achievements.

Multiple Objectives

Most media systems have multiple objectives and the problem remains of how to achieve an overall evaluation. In practice most measures are single-dimensional, with the evaluator concentrating on one particular measure of benefit which is thought to be most important and/or easiest to measure such as cognitive test scores or some other measure of teaching benefit.

Where other objectives are identified their achievement might also be measured. Non-cognitive objectives might be assessed through attitudinal tests, access objectives through a survey of student characteristics and so on. These different measures of benefit might then be put side by side without any attempt at integration, the evaluator leaving it to the reader to subjectively decide between the relative importance of the different objectives. For example, and to simplify matters, let us assume a media system is introduced with two specific objectives: to ensure that the percentage of secondary education age children in rural areas receiving schooling is raised from 75 per cent to 100 per cent, and to ensure that the schooling received should be of equal standard to that in traditional education as measured by an external public examination.

After a sufficient period of time the system is evaluated and it is found that the participation rate has risen from 75 per cent to 90 per cent, indicating a 60 per cent success rate in achieving the access objective. In measuring the cognitive objective, however (and assuming the measure is an accurate and reliable one), it is found that students using the media system have a mean score some 15 per cent below those using the traditional system.

This information can simply be presented, leaving it to the reader to make his own judgment of the overall merits of the system. In this case it depends on how he values the 60 per cent achievement of the participation objective against the relative under-achievement of the cognitive objective. If he was trying to assess the relative merits of the traditional and media systems, he would have to assess, or set up an experiment to find out, what the increase in participation would have been if the traditional system had been expanded in the rural areas. He would then assign weights either explicitly or implicitly to the different objectives in order to provide an overall evaluation. If he was interested in a cost–benefit analysis he would then relate these overall evaluation measures to cost estimates of the different systems.

There are still problems, however, even with this simple example in relating an increase in participation rates from 75 per cent to 90 per cent to an under-achievement of 15 per cent on cognitive scores. There is no common unit of measurement by which the two objectives can be compared.

One way of overcoming this is to adopt a ranking system (say from 1 to 10). The basis of this system is that, for any objective, different levels of achievement are ranked on a scale so that differences between scores on the scale are regarded as internally consistent for each objective. In other words a movement on the scale from say 4 to 5 is regarded as having the same value as a movement from say 8 to 9. However, whilst the top score, say 10, is regarded as the highest or best for any particular objective, there is no need to regard the highest rating of all objectives as having the same value.

The next step is to assign weights to each objective to reflect the relative importance of each objective to the person making the judgment. The implication of the weighting and ranking system is that any two objectives which when weighting and ranking are put together produce the same numerical total must have equal value. Thus in our example above suppose that the 60 per cent participation rate is given a ranking of 6 and the 15 per cent lower cognitive achievement a ranking of 3. On the other hand, cognitive achievement is regarded as twice as important as participation rate, so that it is given a weight of 2 to 1. On this basis the achievement of the two different objectives have equal value and the total benefit in ranking terms is given a value of 12 (weight of 2 × ranking of 3, and weight of 1 × ranking of 6).

Now if this system was being compared to an alternative of expanding education in rural areas through a traditional system the benefits could be compared. Suppose the traditional system achieves only 40 per cent of the participation target but only under-achieves the mean cognitive test score of other students by 10 per cent. The rankings given to participation might be 4 and to cognitive scores 5. Given the double weighting to cognitive achievement the overall score would be 14 ((2 × 5) + (1 × 4)). So on this basis the traditional system would produce the greater benefit.

Klees and Wells (1977) suggest an overall formula for expressing the above procedure, namely

$$T_j = \sum_{=1}^{n} W_i S_{ij} \quad \text{for all } j = 1, \ldots K$$

where T_j is the total score for alternative j;
W_i is the weight assigned to objective i;
S_{ij} is the score of alternative j on objective i.

It is evident that such an approach, whilst useful in making explicit what is often hidden and in providing an unambiguous evaluation of benefit, is also extremely sensitive to the weights applied. Its chief value lies not in providing some magic formula which mysteriously provides an answer where none existed before but in forcing subjective judgments to be explained and their implications analysed. In this connection the correct approach is to carry out a number of calculations using different weights to assess the sensitivity of the measurements to different subjective judgments. The final statement of any evaluation should not be that *A* has a higher benefit than *B* but that the relative position of *A* to *B* in terms of benefit changes in the following ways according to the following weightings.

Another problem with this attempt to concretise the measurement of benefit is that it can lead to a concentration on those objectives which are more easily measured and quantified. Cognitive test scores and participation rates are more easily measured than attitudes. Achievement on a course is more easily measured than satisfaction with it or contentment whilst studying it.

This criticism is forcibly expressed by Carnoy and Levin (1975) in a survey of a number of studies evaluating educational media:

> Consider that in almost all cases a narrow measure of educational attainment or no measure of effectiveness is used at all. Is it appropriate to assume that students receiving video tape instruction in factories are receiving the same education as those on campus who have regular access to faculty, other students or libraries? Is it correct to assume that the value of an Open University degree will be similar to one from Oxbridge or the 'Red Bricks'? Such a presumption simply ignores the credentialing effect of higher educational institutions as well as the fact that Open University students are not being socialised in the same way as their counterparts in traditional universities. The latter students are spending most of their time in contact with fellow students, faculty and academic facilities that go far beyond the short exposure to course instruction and required instructional materials.

Carnoy and Levin argue that there is a benefit of doubt (BOD) bias to evaluations of educational media, namely that where the data are inadequate or unobtainable the measures used tend to favour the media system.

Of course, the BOD assumptions on benefits are widespread throughout the literature. These are based upon the assertion that comparisons of newer educational technologies with the more traditional alternatives show no significant differences between the two approaches on student test scores. Generally such evidence is based upon testing a relatively narrow domain and generalising this to all educational impacts (Chu and Schramm, 1968; Schramm, 1973; and Jamison, Suppes and Wells, 1974). Indeed, Jamison and Klees rely upon these studies in their global statement that '... these media [educational TV and radio] are good substitutes for conventional instruction of reasonably high quality'. Yet none of these studies considers the other factors that are evident in traditional instructional systems that affect both cognitive and socialisation outcomes. Further, recent analyses of the determinants of earnings suggest that congnitive factors are not very strong predictors of income and other measures of lifetime success; and that the non-cognitive aspects of school socialisation seem far more important factors in determining such outcomes (Gintis, 1971; Bowles, 1973; Bowles and Nelson, 1974).

> By omitting these other factors the claims of 'equal success' in educational results is unsupported and derives from a narrowing of what constitutes success to the specific test instrument used to assess instruction rather than to assessing the wide range of outcomes that schooling contributes to (Carnoy and Levin, 1975).

Carnoy and Levin introduce an important cautionary note into the evaluation of educational media benefits. Clearly the educational media experience is different from the conventional learning experience and may produce different outcomes which are often ignored. Even when they are not ignored they cannot easily be measured. What is not clear, however, is the extent to which these other non-cognitive outcomes are regarded as important, particularly by those deciding to introduce the media system. Is the cognitive test most often used because it is the objective decision-makers value most highly, or simply because it is the easiest to measure?

4.3 PROBLEMS OF COGNITIVE MEASUREMENT

Some of the general problems of using cognitive test scores were discussed in Chapter 3. These included the relationship between the test syllabus and the course syllabus, the need to measure learning gain through pre- and post-tests, not just post-course performance, and the need to isolate the effect of educational environment by separating out other influences on the student performance. It is now necessary to discuss some more specific difficulties relating to the measurement of the benefits of educational media.

Wells (1976) raises a number of points including the problem of the time gap between the exposure of the students to the learning system and the administration of the test.

> Very different effectiveness results may be encountered if one tests immediate knowledge of a concept, overall learning at the termination of

> the course, or retention of knowledge after some period of time. An individual's knowledge may be different at these different times, and it is possible that a change may be correlated with the type of system used (p. 79).

Different effects on short- and long-term memory and understanding may be an important factor in comparing two systems. Wells's statement is a plea that evaluators should be aware of this potential difference in setting up their tests, for in nearly all studies the testing of this potential difference is not an explicit objective. Indeed, most tests implicitly test short-term memory and understanding only. They are usually given immediately at the end of a course. Further testing after some delay might yield interesting results and point up differences between conventional and media-based systems of tuition.

A major problem in comparing the cognitive effectiveness of media-based instruction with that of conventional instruction mentioned by Wells (1976) is that of isolating the specific effect of the media on performance. Even if the tests have been standardised as discussed previously, there are other factors, such as instructor, materials, and class composition and size which may all affect performance. Should these be identical for the two systems or should flexibility be allowed so that each medium can be organised to its best advantage? There is some evidence that media differences may not be the most important factor in student success. Chu and Schramm in their survey of research concluded that 'effective use of television grows out of attention to the basic requirements of good teaching rather than to any that might be peculiar to television' (1967, p. 180). If the same teacher finds one system easier to use than the other, this may be the main cause of any differences in student performance. A different teacher may produce an alternative result.

Briggs *et al*. (1967) make the point that the inflexibility in designing comparisons between conventional and new media systems may be a cause of the 'no significant differences' finding mentioned earlier:

> When a lengthy course or sequence, representing several kinds of learning, is prepared in two different media and the results analyzed, the most frequent result is a failure to demonstrate a significant difference. One reason for such a finding could be that each of the media compared was more effective for some elements of instruction and less effective for other elements, so that the differences in effectiveness among media were cancelled in the overall analysis.

The correct approach depends on the purpose of the research. If the object is to see which system achieves the best results with a fixed set of parameters such as course content, instructor and material then it is appropriate to attempt to vary only the medium of instruction. Many situations in which new media are introduced are of this nature. A particular course, its instructor and set of students exists, and the only question is whether introducing television, radio or computer instruction would improve student performance. In other situations the research may be designed to answer the more general question of which conditions suit which medium best. Here the utmost flexibility and variety is desired and a series of experiments each stressing different variables is needed. Indeed this is the only way one will be able to resolve the issue of which conditions suit which system best.

Wells also highlights a factor which is often forgotten, and that is the quality of the instructional materials. Studies of media systems sometimes become obsessed with the hardware. Yet just as the lecture theatre is as good or bad a medium of instruction as the instructors performing in it, so a television screen or radio set is as good or bad as the quality of the material it puts out and the instructors using it. There is some evidence (see Wells, 1976 and Attiyeh *et al.*, 1969) that in any system differences in the quality of materials have a significant effect on student performances. One of the problems for educational media is that hardware developments outstrip software developments; what Andrew Molnar (1970) has called the problem of 'equipment but no materials'. Whilst a great deal of attention is paid to technical refinements to machines, relatively little is paid to the educational material which the machine disseminates. Often in research reports a criticism of a medium is simply a criticism of the material it puts out and uses.

One has to tread a little carefully here. The argument that the problems of using educational media result from inadequate materials is a legitimate one. However, it can be extended to a more general view that if a medium is shown to be educationally ineffective this must arise from it not being used properly. In other words, a presumption exists that an educationally effective use of the medium is always possible. The investigator is put in a 'catch-22' position that any result which indicates ineffective use is explained by improper use. The effect of two different systems on different ability levels of students was discussed in Chapter 3. There it was raised in the context of whether a certain percentage learning gain is of equal value if it raises low-ability students to medium performance levels or medium-ability students to high performance levels and so on.

More generally different media may be more appropriate for different groups of students. Research has indicated that the individualised instruction made possible by using computers can help lower-ability students more than traditional classroom instruction. Computer-assisted instruction can also benefit the introverted student who becomes intimidated by large group classroom instruction. From all this it emerges that the specific characteristics and conditions of any particular research must be carefully studied before the results can be evaluated. As Briggs *et al*. (1967) point out, the finding of no significant differences may simply mask a collection of individually significant factors which in the aggregate cancel each other out. The importance of any particular experiment may lie in helping to identify successful or unsuccessful characteristics of media use rather than in contributing to any generalised statement about significant or insignificant differences. In the words of a writer many years ago:

> The problem that must be solved is not the question 'Is method A better than method B or method C?' but rather 'What are the conditions under which method A produces more effective results? What are the situations where method B is best etc.' (Spence, 1928, p. 462).

4.4 WIDER MEASUREMENT OF BENEFIT

The arguments of Carnoy and Levin (1975) that cognitive achievement is too narrow a measure of educational benefit have already been discussed. There is, however, a wider concept of the effect of media systems without which discussion would not be complete. This is the effect of media on the broad relationship between the education system and the economy, and it is one which economists naturally are interested in.

Education and economic growth

In Chapter 3 rates of return were introduced as a measure of educational output. More precisely the rate of return measures the effect of educational output on the economy. The rate of return is calculated by relating differences in earnings of people with different levels of educational achievement to the costs of their education. The private rate of return relates their post-tax earnings differences to the private costs they have incurred. The social rate of return relates their pre-tax earnings to the costs that society has incurred. It is the social rate of return which measures the benefit to the economy. The assumption behind this view is that the generally observed relationship between higher levels of educational achievement and higher levels of income reflects the greater contribution to output and economic wealth that the more highly educated provide.

Indeed this relationship provides the impetus in most countries for the expansion of education. In developing countries the emphasis may be on primary and secondary education expansion to raise levels of literacy and numeracy. In more advanced countries the emphasis may be on technical and higher education to raise the level of scientific, technical and analytical skills. Wherever the emphasis is laid it is usually the assumed relationship between education and economic growth which is the motivation.

Controversy arises, however, over which elements of the educational process contribute most to economic performance. The assumption behind much of the literature on rates of return is that it is cognitive skills, be they the literacy and numeracy of elementary education or the higher-order analytical and scientific skills of higher education.

Carnoy and Levin, as we have seen, argue that the affective elements of education are of equal if not greater importance. This argument is based on the work of Gintis and Bowles, amongst others, and is linked to a sociological analysis of the role of education. It argues in brief that advanced industrialised economies[2] require certain characteristics from their labour force in order to be successful. With mechanisation and automation these characteristics include efficient timekeeping, willingness to accept orders and the ability to undertake routine, repetitive tasks. It is these characteristics which schooling inculcates in young people which makes them suitable fodder for the industrialised economy.

These are controversial views but two factors are often missed in discussing their merits. First it is often assumed that the cognitive versus affective skills discussion is an either/or comparison. In reality it is a matter of relative importance. The socialisation thesis of the function of education systems seems a highly probable one. Whether it dominates the cognitive skills function, as Carnoy and Levin argue, is much more debatable.

Second, an evaluation of media effectiveness is perfectly able to accommodate the socialisation thesis. Provided adequate measures can be found, the media system can be tested against the conventional system to see which achieves these objectives best. The problem is finding adequate measures. There is no problem in principle in evaluating media in these terms but in reality it has not happened. We are left with the unanswered question previously mentioned. Is the concentration on cognitive skills a result of a conscious understanding that this is the main objective of the system or because other measures covering affective influences are not available?

Education and distribution of income

There is another element to the relationship between education and the economy and this is its effect on the distribution of income. In other words education can affect not just the size of the cake but the way it is divided up. Conventional economic analysis has had little to say about this aspect as the radical critics have not hesitated to point out. In so far as there is a view it is that higher economic growth, by giving everybody a larger slice than before, overcomes distributional problems. More education leads to more growth and each individual gets his share on the basis of his contribution to output which is determined primarily by his educational achievement. Thus everybody is better off than they were before and whilst the relative position between people may not change this is not the important factor.

The radical critics have always scoffed at this approach by emphasising that distributional questions are at the heart of the matter and that the selective systems in education are class-based, or if one does not subscribe to a Marxist analysis, income-based. Thus it is the middle and upper classes and higher income groups which in advanced economies obtain the greater access to higher education and in developing economies obtain access to secondary and higher education.

Thus vicious and virtuous circles set in. The poor receive lower levels of education which ensure they stay poor. The rich receive higher levels of education which ensure they stay rich. Some individuals jump the great divide through upward social mobility but the broad relationships stay the same.

This radical critique is familiar enough but it has recently been reinforced by a firmly non-radical or at least non-Marxist contribution. Fred Hirsch, in a recent remarkable book (1976) analysed the reasons why economic growth has not brought with it a greater sense of well-being. Hirsch makes a distinction between material goods and positional goods. Material goods are those physical goods and services where increased mechanisation leads to an improvement in productivity without any loss of quality. Positional goods are those goods and services and work that are scarce in some absolute or socially imposed sense or subject to congestion or crowding through more extensive use. Travel and leisure facilities are obvious examples of this second category but Hirsch also includes education.

Education is a positional good, Hirsch argues, because it provides access to the best jobs which are in scarce supply. The goals of expanding educational opportunity will not be achieved when education is seen by individuals as a route to the best jobs which are not capable of expansion.

> The utility of expenditure at a given level of education as a means of access to the most sought after jobs will decline as more people attain that level of education. The value to me of my education depends not only on how much I have but also on how much the man ahead of me in the job line has. (op. cit., p. 8).

> To the extent that education in fact functions so as to sort out those who can best survive or master an educational obstacle course, improved performance by some worsens the position of those who would otherwise be ahead. The 'quality' of schooling in effect exists in two dimensions. There is an absolute dimension in which quality is added by receptive students, good teachers, good facilities and so on; but there is also a relative dimension in which quality consists of the differential over the educational level attained by others. The enormous resistance induced in both the United States and Britain by public attempts to integrate previously inferior schools with previously superior schools cannot be fully understood without reference to both these aspects of educational quality. Even if complete assurance could be given that absolute quality would be fully preserved, the previous incumbents of the superior schools would still lose their edge. This loss in turn can be expected to induce them to demonstrate their proficiency in a tougher or larger course of study. To the extent that education is a screening device then the possibility of general advance is an illusion.
>
> What is possible for the single individual is not possible for all individuals – and would not be possible even if they all possessed equal talent. Individuals, whether shopping for educational advance in the market-place or pushing for education through political demands, do not see the break between individual and social opportunity; that is they do not see that opportunities open to each person separately are not open to all. It follows that response to individual demands of this kind whether in market processes or in public provision cannot deliver the order. (op. cit., pp. 5–6).

Given that there is this limit, the radical critics have seen a very clear purpose to the use of media. They argue that it is a method of providing for an expansion of educational opportunity without providing for greater social mobility. Thus Carnoy and Levin argue:

> The Open University seems to be the solution to pressures for university training for working class youths but only for a university training which increases some competencies without necessarily providing credentials

for higher paying jobs which are reserved for graduates from the 'real' universities. We think that if a study were done following up on the Open University graduates, the results would show that they are in a relatively similar position to that of the graduates of *education basica* in Salvador and that of the graduates of Telesecundaria schools in Mexico once that system expands: the kinds of jobs which have been available to university (or secondary) graduates in the past are not the kinds of jobs the graduates of television education are getting. Their pay will be lower, and their unemployment rate will be higher. This is not because their cognitive knowledge in certain subjects will be less than that of their counterparts; it is because they have not had the same social experience as the others, and it is because educational television has done nothing to counteract the class system which governs these societies. At the same time the increase in the supply of persons with these educational attainments will far exceed the increases in job openings for these levels.

The three examples we have discussed above only serve to illustrate the essential point: educational media can be evaluated in terms of narrow educational objectives but this ignores the overall role that educational media will play in affecting the welfare of the people subjected to it. If the educational objectives used to evaluate the effectiveness of media have little relationship to economic and social welfare the evaluations are meaningful only in that they obscure the more significant effect that media may have in maintaining an economic or social system which is unjust and inefficient in terms of people's basic economic and political needs (Carnoy, 1975). This is not to say that teaching cognitive skills as effectively for less resource cost is not a worthwhile objective, but the economic and social effects of producing more of these cognitive skills will tend to be very small in societies which are not geared to utilize them in the economic and social system To the contrary, the introduction of media (with all the fanfare which surrounds educational expansion through media) may serve to temporarily quell legitimate demands for social change and thus forestall that change. It is no accident that the largest ETV projects to date – in El Slavador and Ivory Coast – are located in countries which have very unequal income distributions; and that neither of these projects is, in practice, distributing schooling any more equally than it has been in the past. Furthermore, both societies are archetypes of dependent economic and social systems; indeed, for the most part, educational television has been organized to provide the types of skills which will foster even greater dependence through the increased need for foreign investment to employ the new workers produced by the expanded school system (Carnoy, 1975).

These powerful ciriticisms are of a different dimension to the measurement problems previously discussed. It is not clear how they can be evaluated or tested and it is not surprising that effectiveness studies to date have been of the micro type testing particular limited objectives. However, the Carnoy–Levin approach is not without support, particularly in developing countries, and future studies are increasingly likely to take these wider effects into account.

5 Media Costs I – Costs Analysis

5.1 INTRODUCTION

At first glance the area of costs seems much more certain and precise than that of benefits. We have seen that in many educational media projects little attempt is made to measure benefit, the implicit assumption being that the educational results achieved by media-based learning will be at least the same as those achieved by conventional learning methods. Alternatively, media-based projects are used in situations where no comparison with conventional methods is available, such as, for example, providing wider educational opportunities for people disadvantaged either physically, mentally or geographically. Here there are few alternatives to the new media and *any* education that is provided is deemed to be a benefit. Even in those projects where a conscious attempt to identify and measure benefits is undertaken it is evident that great areas of uncertainty exist.

By contrast the area of costs is much clearer. Every project incurs costs and these must be accounted for. Costs can be identified in terms of men, materials, machines, etc., and these physical resources can be valued in terms of prices paid. Because of this, costs data on a project, unlike benefits data, invariably exist, if only to enable budget planning and control to take place. Whilst a project might not have its educational psychologist or technologist to evaluate benefits it will always have its accountants to measure and control costs. Project planners may not always be required to justify the educational value of their projects but they have to account for the money being spent. Thus costs data are usually more readily available than benefits data.

This availability of data is one reason why costs analyses of educational media projects are far more widespread than benefits analyses. A second factor is the needs of decision-makers. Even if those responsible for a decision do not mistake cheapness for efficiency, they certainly seem to prefer cost–effectiveness analysis to cost–benefit analysis. 'What is it costing?' is a much more frequent question than 'what are the benefits?'

5.2 COST CONCEPTS

Total costs

The question 'what does it cost?' is meaningless without some indication of the size of the activity. The total cost of providing for 2000 students will be different than providing for 1000 students. More formally:

$$TC = f(n)$$

where TC = total costs
n = output.

The first step, though a simple and obvious one, is nevertheless important; for by establishing the basic premise of cost functions, namely that costs are related to (or are a function of) output, one is opening the door to the complex and sophisticated world of cost analysis. An understanding of cost functions not only provides insights and answers to the questions that decision-makers ask, but can also suggest the appropriate questions to be asked.

In some circumstances the *total* cost of a project may be the most relevant question. The finance officer of an institution, when faced with a request for a new audio-visual system, may mean simply that when he asks 'what's it going to cost?' Similarly, though on a larger scale, an international funding agency, when faced with a request from a developing country for a new telecommunication system to bring education to remote parts, may in the first instance be interested largely in the total costs, or the 'bill' they are expected to pick up.

Average cost

Total costs analysis provides useful but limited insight into the costs of a project. It is most obviously relevant at the initial planning stage and can also serve as a budgeting and accounting tool on an ongoing basis. The same data which provide the total cost function, however, can also be presented in a different manner to yield an average and marginal cost function.

The average cost function is the total cost function divided by the units of output produced. In education the number of students is usually taken as the output measurement although in some cases the number of graduates is used instead. So the average cost would be stated formally as:

$$AC_n = \frac{TCn}{n}$$

where AC = average cost
TC = total cost
n = units of output (students).

An average cost function is more useful than a total costs function in comparing projects in that it enables unit costs to be calculated and compared. The statement that 'Project A costs $100 per student and Project B $125 per student' is of more value than 'Project A costs $100 000 and Project B $150 000'.

The calculation of average costs raises the problem of finding an acceptable measure of output. In most cases the student is taken to be the output of the system and student numbers are used as the quantitative indicator. In some cases graduate numbers may be taken. This effectively eliminates from any measure of the output of a system any students who fail to achieve satisfactorily the objectives of the course the system is designed to teach. Pursuing the industrial analogy introduced in Chapter 3 this is similar to not including in the output of a motor factory any cars that fail the quality control procedures before they leave.

In many cases, however, it is necessary to provide a more sophisticated measure of output than simple student or graduate numbers. Ideally, as explained in the previous chapter, teaching output as measured by test scores should be used. Where these are not available, however, it is still possible to produce more sensitive indicators of output than simple student numbers. For example, different types of students impose different costs. It would clearly be unfair to compare the average cost per student of a system designed for primary-school children with one designed for higher education. This is perhaps obvious but even in comparing two sub-systems ostensibly catering for the same group difficulties in standardising output comparison exist. The cost of providing arts-based higher education is generally accepted to be lower than the costs of providing science-based higher education. A cost per student comparison of two systems catering for different proportions of the two types of student, albeit within the same system, is likely to be misleading.

Often the comparison is made not between two media projects catering for different student populations but between new media and conventional instruction as alternatives for the same group of students. Here the output standardisation problems mentioned in the previous paragraph do not occur but there may still be a need for a more detailed breakdown of output than simply student numbers.

Perhaps the most important variable to be added is time. Often this is done in terms of years so that the output measurement reads 'students per annum' and the costs function is expressed as 'annual average costs per student'. In some cases, however, this may be too blunt. Within a year or even a month some systems may be used more intensively than others. Suppose both conventional and new media systems are used to teach students over the course of a year, and it is found that the annual average cost per student is the same in both cases. However, on closer examination it is found that whilst the conventional system is used by students for 10 hours a week the new media system is used for 20 hours a week. In terms of student use the new media system clearly has a lower average cost. A simple annual average cost per student calculation would mask this difference.

This of course begs many questions. Does the more intensive student use lead to better performance? If it does not, and if for example students need to use the new media system for twice as long as the conventional system to achieve the same results, then student intensity of use will be reflected in the simple student number figure. The average costs per student figures will accurately reflect the different costs of using the different systems to teach the same group of students. If the intensive use leads to better results then this might be shown in the output figures. We are back to the problems of obtaining a quantitative measure of output change as discussed in the preceding chapter. The implicit assumption of costs analysis is that in the absence of contrary evidence an hour of use of each system yields the same educational benefits. Thus differences in the intensity of use are relevant for costs analysis.

For this reason the term 'student contact hour' is often used as a measure of output, particularly when the costs of using new media on a particular course or set of courses are being analysed. 'Student contact hours' measures not only the numbers of students but the numbers of hours they use the system. For example, if 20 students receive a 1-hour lecture and a 1-hour tutorial per week on a 30-week course the student contact hours over the whole course are 1200 (20 × 2 × 30). If as an alternative the same course can be taught to 50 students for 1 hour a week for 20 weeks the student contact hours would be 1000 (50 × 1 × 20). An average costs function that relates total costs to student contact hours will be more useful in this example than one that simply uses student numbers per annum.

Marginal costs

Average costs functions are those most often used in the costs analysis of educational media projects. Almost every analysis includes an estimate of average costs per student or student contact hour.[1] It is possible, however, to arrange the costs data to provide a marginal cost function. This measures not the total cost or the average cost per student of a project but the extra or marginal costs of adding (or reducing) output. More formally:[2]

$$MC_x = TC_{n+x} - TC_n$$

where MC = marginal cost
TC = total cost
n = original measure of output (students)
x = additional units of output (students).

Total, average and marginal cost functions essentially present the same data in different ways and for different purposes. The largest operational difference is perhaps that whilst total and average cost analysis is most useful either at the start of a project or as a reporting mechanism once the project is under way marginal cost analysis is most useful as an aid to decision-making. The institution, country, or funding agency with a system in operation and wondering whether to expand or contract or how best to expand or contract will find marginal cost analysis most relevant to its consideration.

The three types of cost functions are, of course, interrelated as total costs are in fact made up of individual marginal costs whilst changes in marginal cost will also affect average costs. More specifically, if the marginal cost of any increase in output is less than the average cost of producing all preceding units of output average cost will fall. Conversely, if marginal cost is higher than average cost the latter will rise. For example, if the average cost per student for 1000 students per annum is \$2000 whilst the marginal cost of taking an extra 100 students is only \$1000 then the average cost of now taking 1100 students falls to \$1909. Thus it is possible to see the effect of marginal costs as output increases by studying the figures for average cost. As student numbers increase if average cost also rises it means that the cost of taking extra students is greater than the average cost of existing students. If the movement is the other way this indicates the likely existence of economies of scale which makes it advantageous to increase output.

Fixed and variable

The basic principle of costs functions is to relate costs to output. It is thus possible to classify the various elements of costs into those that change with output and those that do not. For example, in a conventional educational system designed for say 1000 pupils the major cost components will be the building, furniture, equipment, etc., teaching staff and materials, and costs of running the building such as heating, lighting, etc. Now for any level of pupil numbers up to 1000 the building furniture and equipment can be regarded as fixed. Indeed, although the building was designed for 1000 it might well be possible to increase numbers above this figure without any extra building costs. Teacher and material costs clearly do depend on the number of pupils, and the same might be said for running costs although here the dividing line is more problematical. There may be very little difference in the costs of heating and lighting the school when there are 1000 instead of 900 pupils. It all depends on how much output is varied. Clearly there would be a difference in running costs between 100 and 1000 pupils.

However, the major point is established in categorising costs that some may be classified as fixed in relation to output and others variable. It is important to realise that this classification of fixed and variable costs relates to the scale of output. In certain circumstances all outputs are variable; in others they are all fixed. In the previous example if one wished to analyse the costs of increasing pupil numbers from 1000 to 3000 then all costs would be variable. Such as expansion would require new buildings, furniture, etc., as well as new teachers and materials. It is only in the range of pupil numbers one to 1000 that the building is regarded as a fixed cost. Alternatively, in considering the effect of increasing pupil numbers from 1000 to 1050 it may be possible to regard nearly all factors as fixed. Such as expansion may be accompanied by adding one or two pupils to each class, the only extra expense being some more materials. Teachers' salaries which had previously been regarded as a variable cost would in this instance become fixed.

This distinction between fixed and variable is linked to the concepts of short run and long run in economics. These concepts often confuse beginning students in economics who assume they are linked to a fixed period of time. They are in fact associated with the scale of change. The short run is a period of output production during which it is impossible to change the quantity of certain factors of production such as buildings and machines. These are regarded as fixed. Thus if output is to be increased it must be achieved by increasing other factors such as labour which can be varied and using the fixed factors more intensively. The long run is regarded as a situation where all factors of production can vary so the distinction between fixed and variable no longer holds. Thus the discussion above refers to a short-run situation where some elements of cost are fixed in relation to output change and others are variable. In fact, cost analysis as a whole in this area is most relevant to short-run situations.

This flexibility in the categorisation of costs between fixed and variable applies also to differences between expansion and contraction. An increase of 25 per cent may require more buildings and teachers and so these items would be regarded as variable. A contraction of 25 per cent may simply imply under-utilisation of a building rather than its withdrawal whilst employment regulations may prevent the sacking of teachers. These factors in this situation become fixed.

5.3 DISAGGREGATED COST ANALYSIS

The analysis so far has concentrated on studying the total, average or marginal costs of a project as a whole. However, cost functions are much more powerful in providing insights into the structure of costs and in guiding decision-making when they are applied to the component parts of a particular system, on a disaggregated basis.

The costs of a particular instructional system can usually be divided into those that arise in producing a master or initial copy, those that arise in producing duplicate copies, and finally those that arise in distributing or presenting the material to students. Not all media conform to this particular threefold classification and there is sometimes overlap between the different categories. It is necessary to be flexible in studying a particular system but the essential point is that it enables the different activities that give rise to costs to be identified and separate costs functions to be specified and applied to these particular activities.

For example, the costs of an educational film could be divided into master costs of initial photography; duplicate costs of making various copies of the film; and distribution or presentation costs of projectors, screen, etc. All these different activities contribute to the final total costs of the film but by disaggregating the analysis the relative contribution to total costs of each of the activities can be identified. More significantly, whereas it may only be possible to relate the overall cost to student numbers as explained earlier, the units of output that are especially relevant to a particular activity can now be separately analysed.

In the case of film for example the master costs of photography are most affected by the hours of film required. The matter is complicated by the fact that it may be necessary to shoot more film than is finally required but this can be allowed for in the cost function. Costs can be divided into those that are fixed and those that vary in relation to the number of hours of filming. It is not possible to generalise on which costs fall in which category. The equipment may be a fixed cost if it is owned but may be a variable cost if it is hired by the hour or day. Some categories of staff might be regarded as a fixed cost in relation to this particular film if they are part of the general staff whilst other staff who might be hired for this particular film at an hourly or daily rate might be regarded as a variable cost. The essence of cost analysis is that it provides a basic methodology which has to be applied to each particular case. A resource which might be regarded as a fixed cost in one set of circumstances becomes a variable cost in a different set of circumstances.

Having expressed the relevant unit of output as the hours of filming it is possible to calculate the average cost of producing final film as follows. Let:

MC = master cost of producing final film
a = fixed costs
b = variable costs per hour of filming
y = number of hours of final film
n = number of hours of filming required to produce 1 hour of final film.

Then $MC = a + byn$

and $AMC = \frac{a}{y} + bn$

where AMC = average master cost of producing 1 hour of final film

The merit of this simple cost function is that it allows the total and average cost of different hours of filming to be calculated and more significantly indicates the effect on costs of changing the values for a, b and n. For example, if a is \$200, b is \$50 and n is 4 hours the function indicates that it will cost \$400 to produce 1 hour of usable film and \$600 or \$300 per hour to produce 2 hours of usable film. It is thus possible to measure the extent of the economies of scale as the number of film hours is increased. For example, if it were possible to obtain 5 hours of usable film (20 hours of actual filming) from the same fixed cost, the average cost of an hour's filming would fall to \$240 per hour. Moreover, if it were possible to reduce wastage so that only 3 hours of filming was required to produce 1 hour of final film the average cost of 1 hour would be reduced from \$400 to \$350 and of 2 hours from \$300 to \$250.

Similar cost functions can be applied to the duplication and presentation costs. For duplication costs the most obvious measure of output is the number of copies required. For presentation costs the number of venues will obviously be important. In this way average master, duplication and presentation costs can be established, and these individual average costs can be summed and then divided by student numbers viewing the film to provide an overall average cost per student. The particular advantage of this approach, however, is that it enables the component parts of the system to be broken down and separately analysed and the implication of alternative assumptions to be explored. An example of this will be shown in Chapter 7 where cost functions of a videotape system are examined.

The medium of film has been used here to illustrate the usefulness of disaggregated cost analysis but the same approach can be applied to other media such as television, radio, tape, slides, computer-assisted instruction and even the very basic medium of a live lecture. In this latter situation the preparation of the lecture would be the master costs, the repetition of the lecture could be regarded as duplication costs or alternatively initial and subsequent presentation could be regarded as presentation costs. The important point, however, is that there is some benefit to separating the costs involved in preparation from those involved in delivery. Incidentally, the conception or intellectual cost involved in the preparation of material is sometimes incorrectly ignored in costs analysis and can, and often should, be separated from the other master costs. In our previous example of film only the actual costs of photography were regarded as master costs whereas the costs of conceiving the idea and writing the script are also a major element of the master costs and would probably be regarded as a fixed cost. This illustrates an important issue, namely the relationship between software and hardware. In calculating educational media costs the emphasis tends to be on the hardware alone and software costs are often ignored. The implicit assumption is that the educational content does not change in relation to the medium used, a position which is not tenable. Most forms of educational media require different and more time-consuming educational inputs than the conventional approach and this implies higher costs.

5.4 COST ANALYSIS OVER TIME

One of the problems of cost analysis is that it presents a picture of the position at one particular point in time. Thus it enables us to say that in year x with a given cost and a given utilisation rate the average cost per student will be a certain figure. We have seen that by disaggregating the cost functions it is possible to show the effects of different cost and utilisation assumptions but this too refers to data at one particular moment.

Yet if cost analysis is to be useful for decision-making it is important to be able to show the movement of average cost over time. As was mentioned earlier the costs position once a project is under way is very different from that before it has started. The decision-maker would find it helpful to know future average costs from the perspective of any particular year and assuming different time-horizons for the life of the project.

Jamison *et al*. (1976) provide a method which enables this information to be obtained. It consists of calculating *AC ij* where *AC* is the average cost, *i* is the year in which the calculation is made and *j* is the time-horizon or life of the project. For any year *i* of a project average costs can be projected forward on various costs and utilisation assumptions for any given life of the project.[3]

To take an example, suppose a project has a 10-year life with high initial costs in years 1 and 2 followed by relatively lower ongoing costs in years 3 to 10. Moreover, student utilisation, measured by student contact hours, starts slowly but picks up towards the middle years and stays at the peak over the last few years. The calculation can, of course, be made for different assumptions but the data for this particular example are shown in Table 5.1.

TABLE 5.1 Total costs and utilisation rate

Year of analysis i	*Total Costs in Year* i	*Student contact hours*
1	10 000	–
2	15 000	1 000
3	5 000	1 000
4	6 000	1 200
5	7 000	1 600
6	7 500	2 000
7	7 500	2 000
8	7 500	2 000
9	7 500	2 000
10	7 500	2 000

These data can be used to calculate the average cost in any year *i* or over any range of years *i* to *j*. The detailed calculations are shown in the Appendix to this chapter and the results summarised in Table 5.2. The procedure is to take the total costs in each year and discount them back to year 1. The discount rate chosen in this instance was 10 per cent. For each year *i* the cumulative discounted costs in each year *j* are divided by the cumulative student contact hours for that year. Thus for example if year 1 is the year of calculation the cumulative discounted costs incurred by year 5 is $37 061 which, divided by the cumulative student contact hours by that year, 4800, gives the figure of $7.72 shown in Table 5.2.

The row of figures in year 1 shows the calculations which are appropriate before the project has started. The figures show that if the project were to last only 2 years it would incur an average student contact hour cost of $23.64 because the whole of the initial cost would have to be spread over the only year of intake of 1000 students. In subsequent years as only variable costs are incurred and student contact hours rise the average cost falls until in the final

TABLE 5.2 Average costs per student contact hour for different years and time-horizons

Year of analysis i	*Time-horizon year j*									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	–	23.64	13.89	10.09	7.72	6.14	5.22	4.61	4.16	3.82
2		15.00	9.77	7.66	6.20	5.13	4.49	4.05	3.72	3.45
3			5.00	4.75	4.27	3.77	3.46	3.23	3.04	2.88
4				5.00	4.42	3.87	3.56	3.33	3.15	2.99
5					4.38	3.84	3.70	3.47	3.28	3.12
6						3.75	3.58	3.42	3.27	3.13
7							3.75	3.58	3.42	3.27
8								3.75	3.58	3.42
9									3.75	3.58
10										3.75

year of the project it is expected to be $3.75. Thus the decision-maker can see the implications of different assumptions about the life of the project and it is possible also of course to calculate the effects of different assumptions about costs and utilisation.

Once the project is under way, however, the relevant costs data are different. In year 3 for example, the large expenditures of years 1 and 2 are bygones. Whatever decision is made about the future use of the system these costs cannot be recouped (except in so far as any buildings or equipment have a resale value if the project is wound up). In terms of opportunity costs, i.e. those costs which use resources for which an alternative future use exists, it is future costs that count. So in year 3 the relevant costs over years 3 to 10 are the costs to be incurred and the student utilisation in those years. The heavy initial costs are no longer relevant and as a result average student contact hour costs are now below $5 and declining fast as cumulative student utilisation increases up to year 10.

The data in Table 5.2 provide a striking quantitative expression of the problems for decision-makers outlined earlier in this chapter. The high initial costs mean that any decision-maker looking at the data from the perspective of year 1 will see high average costs in the early years of the project with the figure only falling below $5 from year 8 onwards. From the perspective of year 3, when the initial costs have already been incurred and are no longer relevant, average costs are well below $5 over the subsequent 7 years and the project looks much more attractive. This is the background to the understandable temptation to under-estimate costs and over-estimate utilisation at the start of the project, thus reducing the figures in row 1. Once the project is under way and the errors are becoming evident in (say) years 3 and 4 it is possible to show that the relevant costs figures in the new situation make it worthwhile continuing with the project.

5.5 SUMMARY

This chapter has introduced the concept of cost functions to indicate the usefulness of cost analysis in helping to understand the costs nature of a media system both in a reporting framework after it has been in operation and also as a management tool to guide decision-making throughout project life. The analysis has moved from the simple concepts of total and average cost through the more complex approach of marginal cost and the relationship between fixed and variable cost on to the sophisticated analyses of disaggregated cost functions and cost analyses over time. In Chapter 7 some practical examples of project appraisals using each of these approaches is given, but first it is necessary to spend some time discussing conceptual and measurement problems that arise in costs analysis.

APPENDIX

TABLE 5.3 Total costs

Year of analysis	*Time-horizon year* j									
i	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	10 000	23 640	27 772	32 280	37 061	41 718	45 951	49 799	53 298	56 479
2		15 000	19 545	24 503	29 762	34 885	39 542	43 775	47 623	51 122
3			5 000	10 454	16 239	21 874	26 997	31 654	35 887	39 735
4				6 000	12 363	18 561	24 196	29 319	33 976	38 208
5					7 000	13 818	20 736	26 371	31 494	36 151
6						7 500	14 318	20 516	26 151	31 274
7							7 500	14 318	20 516	26 151
8								7 500	14 318	20 516
9									7 500	14 318
10										7 500

TABLE 5.4 Student contact hours

Year of Analysis	*Time-horizon year* j									
i	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	–	1 000	2 000	3 200	4 800	6 800	8 800	10 800	12 800	14 800
2		1 000	2 000	3 200	4 800	6 800	8 800	10 800	12 800	14 800
3			1 000	2 200	3 000	5 800	7 800	9 800	11 800	13 800
4				1 200	2 800	4 800	6 800	8 800	10 800	12 800
5					1 600	3 600	5 600	7 600	9 600	11 600
6						2 000	4 000	6 000	8 000	10 000
7							2 000	4 000	6 000	8 000
8								2 000	4 000	6 000
9									2 000	4 000
10										2 000

6 Media Costs II – Problems of Costs Analysis

6.1 INTRODUCTION

The previous chapter has indicated the potentiality that exists for costs analysis to provide insights into the costs structure of media projects. This potentiality, allied to the easier availability of data and the pressure from planners and decision-makers for information, makes an analysis of costs a much more attractive area of enquiry than an analysis of benefits. These pressures, however, can be dangerous for they can lead to the very real conceptual and measurement problems involved in costs analysis being overlooked. The relevance of the costs analysis depends on the purpose for which it is required. Different variables are relevant for different questions. Estimating the total costs of a project requires a different analysis than estimating the average costs per student. And an estimate of costs in the future requires a different analysis than an estimate of costs in the past. The costs relevant to deciding whether a project should be continued, expanded, reduced, or abandoned are different from those relevant to whether it should be established in the first place. The costs which are relevant from a funding body's point of view may be different from those relevant from an institution or student's point of view. And costs collected at one point in time on one project may not be relevant to costs collected at another point in time on another project even if the analysis on both projects is designed to answer the same question.

As a result the scope for making any generalised statements about the costs of educational media projects from comparing individual studies of particular projects is limited. It does not help very much to know that the average cost per student contact hour in one project was $5 and in another project $7 without knowing the detailed background, costs and utilisation information relevant to each project. If a large number of varied projects with different backgrounds, costs and utilisation rates all produce average costs per student contact hour within a given acceptable range this would be an interesting result capable of a generalised statement. But it would be of only limited use to a decision on a future project with its own background, costs and utilisation data.

What can be generalised is not the actual results of a particular project but the methodology which is applied to produce these results. The importance to costs analysis is the provision of this generalised methodology which can be applied to different projects, different sets of data, different institutional contexts and different questions to provide specialised information and insight relevant to those projects, institutions and questions.

Costs identification

The identification of costs is not straightforward. There are hidden costs such as time which may not be fully reflected in the costs incurred. For example, whilst the use of staff time can usually be assumed to be reflected in the salaries paid to staff, is the use of students' time equally reflected in any system of payment? And does the use of such time really matter in a cost calculation? Well, it might. A system designed for use by students full-time is likely to incur a different structure of costs than one used part-time. The impact on the wider society is also different. In the first situation students are withdrawn from employment for a period of time, whilst in the second they continue to produce output for the economy whilst studying.

This highlights another important question for costs analysis. Whose costs are we talking about? The external funding agency may only be interested in the total cash bill at the end of the day and may thus favour a scheme which uses more student time (for which no charge is made) and less staff time (which has a price). The country itself may prefer keeping its students at work while they are studying. Although this may mean higher staffing costs, the country as a whole gains from the output the students are producing whilst they are working. It is unlikely, therefore, that a simple generalised answer to the question of the total costs of media projects is available. It is necessary first to identify 'what costs' and 'whose costs' we are talking about.

Measurement

Even if the problem of costs identification is overcome, the measurement of costs by taking the price of components may not always be appropriate. First, of course, some costs may not have easily identifiable prices attached to them. For example, if it is decided that student time should be costed in the sense that a system that requires greater student input, other things being equal, is considered to be more costly than a system requiring lesser student input, how is this time to be valued? This problem is closely related to the previous one of costs identification.

But even where prices are available as an indicator of costs, such as, for example, the price of a television camera, it is necessary to be cautious. This is not just a problem of costs estimation in the sense that it is necessary to know not what the camera costs now but to forecast what it is likely to cost in a year's time when the project is implemented. There is a more fundamental problem of what prices reflect. There is a well-established economic theory that under certain competitive conditions prices reflect the costs to society of producing the good in question. But if these competitive conditions do not exist prices may reflect other factors, more specifically the monopoly power of producers. In calculating the costs of a project from a country's point of view do we take these prices as given? We are back very much with the question of 'whose costs?'. The finance officer of an international funding agency might be forgiven for being a little impatient with such questions. He would argue that the cost of a piece of equipment is the price he has to pay for it and if this price over-estimates its worth to society this is tough luck. He has to live in the real world and he is quite happy to leave such philosophical questions to academic economists.

This understandable attitude is perhaps appropriate for an individual institution concerned with the costs to itself of a particular decision, and faced with costs which it cannot influence. National or international bodies are, however, in a different position. They are obliged to take some notice of 'society's' interest and moreover they may be in a position because of their status and authority to influence prices. Moreover the question of the meaning of prices is not simply an academic one but a very practical issue for developing countries and applies to all investment projects, in transport, health, industry as well as education. It is particularly relevant to foreign exchange conversion problems – does the official exchange rate reflect real differences in the purchasing power of different currencies? – and an advanced and sophisticated literature has been developed to deal with these problems (see for example Little and Mirlees, 1969).

6.2 NEW MEDIA VERSUS CONVENTIONAL TECHNIQUES

Difficulties often arise because it is sometimes assumed that the cost analysis of media projects is no different from conventional educational approaches. A basic difference between media and conventional methods in education is that the former requires a greater investment of resources before output is produced. More specifically a system using audio-visual or computer learning technology requires a large capital investment in hardware as well as the employment of a substantial proportion of the final number of staff to produce programmes and courses before a single student has enrolled. The costs that are thus incurred are to all intents and purposes fixed until the number of students has reached the maximum utilisation level. At this point more factors become variable as decisions on the best method of expansion have to be made.

It should be emphasised that the *nature* of the costs distinction between fixed and variable is little different for new media and conventional methods. In the example given in the previous chapter of the school established for 1000 pupils the same situation existed of a capital investment on buildings, etc., the engagement of staff before pupils had been enrolled and so on. The type of problem faced and the breakdown of costs into fixed and variable with respect to student numbers was the same. It is the *size* of the problem which is different. The fixed element of costs in a media system is likely to be larger both in absolute size and as a proportion of total costs than in a conventional system.

This distinction is important to the decision-maker at the outset of a project. For he not only wishes to know the final total costs at a given output or student usage but the irreversible costs once he has given the go-ahead. This by and large is what the fixed costs measure. They are the size of the commitment which will have to be met even if no students turn up to use the system.[1]

The size of initial costs is one reason why the fixed/variable categorisation is important in decisions on media systems. In addition the estimates of both costs and output are likely to be more uncertain than for conventional instruction. As far as the latter is concerned on the costs side a great deal of data is available from existing systems so that it is possible, given the technical specifications of the system, to provide an accurate estimate of both fixed and variable costs. On the output side most conventional systems are introduced to meet a known demand, either through a rise in pupil or student numbers which can be accurately forecast or as a result of a decision to provide education to new groups in the population.

In contrast although increasing evidence is becoming available on the costs of different media (see for example Jamison *et al*., 1976) much of this is not generalisable and is mainly useful in the specific context of the project itself. New media projects tend to have as many points of difference as similarity and in addition inevitably the media themselves change quickly so that even providing similar technical specifications may not yield similar costs data. On the output side there is also less certainty. In higher education new-media systems are often used as alternatives to existing conventional systems for a given population and the rate of switch-over is not easy to forecast. Alternatively media may be used to expand opportunities for hitherto deprived groups whose rate of take-up cannot be accurately predicted.

Thus the forecasts on costs and utilisation are likely to be less accurate for new-media systems than for conventional systems. Furthermore, these difficulties are compounded by the greater sensitivity of the forecasts to errors in costs or utilisation data. Conventional systems usually have a lower ratio of fixed to variable cost and are on a much smaller scale. For example Laidlaw and Layard (1974) calculated that the ratio of fixed cost to variable cost per student for an arts course on a traditional UK campus university was in the region of 4 : 1. An arts course at the Open University using distance learning materials of print and broadcast was in the region of 2900 : 1. As far as scale is concerned, the decision to build a secondary school in the UK involves capital expenditure of less than £1 million (mid-1970s prices) and a pupil forecast of about 1000. The effect on total or average costs per pupil of under-estimating costs or over-estimating pupil use will not be too dramatic is cash terms. In contrast a relatively modest project to provide an educational television service for Inner London schools involved a capital cost well in excess of £1 million (mid-1970s prices). The service was available to some 1200 schools in the area but the use of the service in each school fluctuated considerably. Thus the average cost per student contact hour was extremely sensitive to differences in student usage. The potential use is so large that it was difficult at the outset to make an accurate estimate! (see Vaizey *et al.*, 1971).

This sensitivity to error in forecasting costs and utilisation is perhaps best exemplified in the estimates produced for PLATO IV, a large-scale computer-assisted instruction system centred in the University of Illinois at Urbana.[2] Because PLATO IV was a development from earlier less sophisticated systems the technology and cost elements were largely known from previous studies. Alpert and Bitzer (1970) estimated a maximum cost of $0.68 per student contact hour. In 1973 the actual average cost per student contact hour was estimated to be just under $7 (Wagner, 1974) whilst a later estimate (J. Austin, private communication) indicated that it had come down to about $4, which is likely to be near to the minimum.

The reasons for the differences are clear. Alpert and Bitzer under-estimated certain items of cost, particularly the curriculum cost in terms of teacher hours required to produce software instructional programs. More important they seriously over-estimated the student utilisation of the system. The original estimates assumed that the system would incorporate 4000 terminals which would be used for 8 hours a day on 250 days a year. This provided a utilisation rate of 8 million student contact hours. In 1973 it was estimated that only 150 terminals were in regular use for an average of 2000 hours per annum. It has now been accepted that the maximum number of terminals likely to be accommodated on the PLATO system is about 1000, and that the average utilisation rate of each terminal may be only a half to two-thirds of original estimates. Thus the utilisation rate is likely to be out by a factor of 5 or 6. As a result, and taking account of the under-estimating of certain costs, average cost per student contact hour is likely to be some 6 to 7 times higher than originally forecast. The PLATO IV system is examined in greater detail in Chapter 7.

Summarising, therefore, fundamental differences exist in the costs structure between conventional and media systems. In the latter the total costs of the system are likely to be greater and a higher proportion of these costs are likely to be fixed independent of student utilisation. Moreover the estimates of these costs and utilisation rates are likely to be less reliable for media systems.

All these factors make costs analysis for decision-making a hazardous business. The costs structure indeed reinforces the temptation to under-estimate costs and over-estimate utilisation in initial forecasts. The biggest decision on a media system is the original one. The decision to go ahead can involve the investment of hundreds of thousands if not millions of dollars. As has been explained most of these costs cannot be recovered once the investment has occurred. The costs of the project in terms of the total size and in terms of average cost per student utilisation are likely to be important factors in any decision, and the fact that media systems tend to have a high overall cost and a high ratio of fixed to variable cost is likely to make decision-makers much more wary of giving the go-ahead.

However, once the project is under way the costs structure tilts to the advantage of the media system. With a lower ratio of variable cost to fixed cost the costs advantage of expansion or contraction almost always lies with the media system. In these situations marginal cost not average cost is the more relevant calculation and the marginal cost of expansion or the marginal saving of contraction will invariably be lower for media systems. It may be difficult to argue the case on cost grounds for introducing media, but once it has been established the argument for expansion and against contraction is relatively easy. The temptation to under-estimate costs and over-estimate utilisation at the outset, particularly in view of the genuine difficulties in making such estimates, is thus very great.

6.3 THE TREATMENT OF CAPITAL COSTS

In many studies of educational costs capital and fixed costs are often regarded as synonymous and indeed the previous discussion came close to confusing the two. In some cases it is true that the costs which are fixed in relation to student numbers are largely capital costs – buildings, etc. – but it is important to realise that it is the fixed nature of costs that we are interested in and not their capital nature. In an audio-visual system for example there will be some items regarded by the accountants as current costs which are to all intents and purposes fixed from the point of view of student utilisation. The salaries of the academic and technician staff involved in programmes are a case in point. The costs of making the programmes would be the same if the programmes are watched by 1 student or 50 000 and these staff costs could be considered fixed. Similarly some items of capital cost might be considered as varying with student numbers, such as for example the number of reception monitors.

At the Open University a large element of staff costs is incurred irrespective of student numbers. The work that goes into producing course materials and radio and television programmes would be required whether 1 student or 1000 students study the course. All these costs are fixed in this sense. On the other hand the cost of summer schools, which includes a cost of renting buildings, is a variable cost clearly depending on the numbers of students who attend. It is important, therefore, not to confuse capital and fixed costs. It is the latter we are interested in and it is well to remember too that, paradoxically, the term 'fixed costs' is a flexible one. A cost is fixed in relation to the unit of output you are using. For example, central teaching staff costs at the Open University are fixed in relation to the number of students but vary in relation to the number of units of course material produced. If more *students* take a course this will not increase the number of staff hours required to produce it. But if more *courses* are produced even if student numbers remain the same this will require more staff hours and thus increase staff costs. An item which is fixed in relation to one measurement of output may be variable in relation to another.

This latter point is very important for it indicates that simple cost analysis in which costs are related to a simple output measure – student numbers or student contact hours – is of limited value. To provide greater insight into the factors which generate costs it is necessary to break down the costs structure into its component parts, analysing in much greater detail the various parts of the system which go to make up the whole.

Whatever the form of costs analysis used the problem of capital costs has to be overcome. Most cost data are generated to fulfil budgeting or accounting needs. The budget officer has to account for all expenditures and is thus interested in the time-period within which expenditures fall. Large capital items complicate this picture because if they were to be included in the year in which they fall the budget would show a large fluctuation. However, from the point of view of forecasting yearly cash commitments it is necessary to indicate all expenditures. The usual method of overcoming this is to separate out recurrent or above-the-line expenditure from capital or below-the-line expenditure.

As the name implies recurrent expenditure covers those items of costs – salaries, materials, fuel, etc., which recur from year to year.[3] Capital expenditure covers items which are incurred at one point of time. However, from the point of view of economic analysis the distinction is misleading. Capital expenditure may be incurred as a lump sum at a particular point in time but the services which flow from that expenditure recur over time. And it is the services that we are interested in. The problem is one familiar to economics from industrial experience in aggregating a stock of equipment which is produced at one point in time but from which services are consumed over a period of time, and a flow of services which are consumed as they are produced.

Suppose an audio-visual system requires a capital expenditure of $500 000 initially and a recurrent expenditure of $100 000 per annum. We have already seen that it would be misleading to regard the $500 000 as fixed costs and the $100 000 as variable cost. However, the capital cost cannot be ignored as a cost of the project and it would be wrong to simply take the recurrent cost as the total cost. A method has to be found of incorporating the capital and current expenditure into a single measure of the cost of the project. This is what economic analysis does by regarding the capital expenditure as payment at one point in time for a flow of services over time. The capital equipment may be installed in year t and may have a life of n years. In each of the years between $t + n$ it is yielding services which should be regarded not as part of the costs in year t but as part of the costs in each of these years. In other words we need to turn the cost of the capital stock into an annual cost of a flow of capital services for each year of the life of the capital. We need to annualise capital costs.

This annualisation requires an allowance to be made for the costs of capital and the wastage of capital. For the time being (although as will be seen shortly the matter is a little more complicated) the cost of capital can be measured by the interest which is required to be paid and the wastage of capital by its depreciation over its lifetime. However, simply adding together an annual interest charge and an annual depreciation charge to provide annual capital costs will lead to an inaccurate estimate. The matter can best be explained with the aid of an example.

Taking the case of an audio-visual system requiring a capital investment of $500 000, suppose this is to be borrowed at a rate of 7.5 per cent with the equipment expected to have a lifetime of 10 years. Using the simple method just mentioned would produce an annual interest charge of $37 500 (0.075 × 500 000) and an annual depreciation charge of $50 000 (0.1 × 500 000) giving total annual capital costs of $87 500.

However, the annual interest payment must be related to the actual amount of capital tied up in the investment each year and not the amount which was tied up at the start. Allocating $37 500 to interest charges each year assumes that the capital retains its value each year over its lifetime and then suddenly depreciates to zero at the end of the tenth year. But we have not assumed this. Instead we have allocated $50 000 to depreciation each year which means that the capital tied up in the investment is reduced by this amount each year. We cannot relate interest costs to the original cost of capital throughout its life *and* assume that the capital is being depreciated each year.

We require a formulation that allows for the effect of depreciation on annual interest charges. The situation is similar to a mortgage which is taken out over the life of the equipment and which is repaid in equal annual instalments. The depreciation charge is equivalent to the repayment of capital so that in the early years interest costs constitute the greater part of the annual payment but in the later years of the life of the capital depreciation becomes the larger element. This annual payment (a) which will repay the costs of a piece of equipment (c) at a given interest rate (r) over a given life (n) can be found by the following equation

$$a = \frac{C\ (r\ (1 + r)^n)}{(\ (1 + r)^n\ - 1)}$$

In our example:

C = $500 000
r = 7.5 per cent
n = 10 years.

Thus

$$a = 500\,000\ \frac{(0.075(1.075)^{10})}{(\ (1.075)^{10} - 1\ )}$$

$$= 500\,000\ (0.146)$$

$$= \$73\,000.$$

The example indicates that using the incorrect method of annualising capital costs over-estimates their value by $14 500 per annum or $145 000 over the lifetime of the equipment. This not inconsiderable sum might make all the difference between the project being considered viable or not.

However, even using the correct method of annualising capital costs does not guarantee an accurate estimate; for the equation given above only provides a methodology: it does not provide the data. More particularly the annualisation equation is extremely sensitive to changes in the rate of interest or the assumed lifetime of the equipment. With many media systems requiring capital investments in millions of dollars small changes in the rate of interest or in assumptions about the lifetime of the project can have a significant effect on annual capital costs. This can best be illustrated by the use of the following example.

In Table 6.1 various interest rates and years of equipment life have been assumed for a capital expenditure of $1 million. The figures show that substantial differences exist in annual capital costs for quite small differences in rate of interest or equipment lifetime assumptions, particularly at the lower end of the spectrum where any change has a greater proportional effect. For example, extending the life of the equipment from 5 to 6 years can reduce annual capital costs by some $34 000. More or less the same effect is produced by reducing the rate of interest from 15 to 10 per cent.

These are not trivial sums. In the example given the annual saving is equivalent to about 3.5 per cent of the total capital cost. Yet often in cost analysis the rate of interest and equipment lifetime assumptions are made

TABLE 6.1 Annual capital cost of investment of $1 million at varying rates of interest and life of equipment ($000)

Life of equipment	*Rates of interest*			
	7.5%	*10%*	*12.5%*	*15%*
5	247	264	281	298
6	213	230	247	264
7	189	205	223	240
8	171	188	204	223
9	157	174	191	210
10	146	163	180	199
11	137	154	172	191
12	129	147	165	184
13	123	141	160	179
14	118	136	155	175
15	113	131	151	171

without detailed justification or at least supporting evidence. Sometimes a costs study will spend more time discussing items of far less quantitative impact such as the correct apportionment of secretarial time or some other overhead cost which is shared between projects. The latter issues may have some political importance, particularly for the respective project heads, but the estimation of the appropriate rate of interest and lifetime of the equipment are much more important economically, and are indeed essential elements in any cost analysis of educational media.

Of course such accurate estimation is easier said than done. The choice of an appropriate lifetime for equipment is largely a technical matter requiring specialist knowledge of the equipment and likely technical developments. With audio-visual or computer equipment the lifetime chosen is a function more of technical rather than physical obsolescence. The lifetimes assumed in many projects seem rather short (rarely more than 10 years) but this may be accurate if replacement for technical rather than physical reasons is the criterion used.

The choice of the appropriate rate of interest is more complex, however. The assumptions in the example above made the choice a relatively easy one. It was assumed there that the costs of a project were being looked at from an institution's point of view and that the whole of the capital sum has to be borrowed. In this situation the annual rate of interest on the amortised capital sum was the annual cost of capital to the institution.

Suppose, however, that the institution has the capital funds available from its own sources and so does not need to borrow. There is now no rate of interest to pay. Does this mean that annual capital costs are reduced and consist only of the annual amortisation charge?

The answer is no, because in reality it makes little difference whether the equipment is self-financed or the funds borrowed. There is still a cost to the provision of funds. Whilst clearly there is a cost in terms of the rate of interest paid if the funds are borrowed, there is also – but perhaps less obviously – a cost if the project is self-financed. The cost consists of the interest that could have been earned or saved if the funds had been invested or used elsewhere rather than in the particular project. For example the institution could have simply placed the funds in a bank deposit account to earn interest if there was no alternative project use for them. This lost or foregone interest is the cost of financing the project. If the funds could have been used to finance another project (B) than the interest on the sum borrowed to finance this other project (B) because the funds have been used on the initial project (A) is an accurate measure of the capital costs of A. This is the concept of opportunity cost. Capital funds have alternative uses and it is their earning power or the money they might save in these alternative uses which determines their cost in the use eventually chosen. It makes little difference whether the funds are self-provided or borrowed. Capital costs have a value because they have an alternative use.

However, this looks at matters from the institution's point of view. Is the situation any different if we are looking at matters from a funding agency viewpoint or from a country's viewpoint? In reality the distinction is not between different types of agencies but between a private or social viewpoint. The institution or the funding agency (particularly a private or charitable agency) may be interested only in the private costs to itself of funding the project. In this case the private or commercial rate of interest where there is an alternative use is the relevant criterion. But where a government or international agency is concerned the private or commercial interest rate may be too narrow. In this situation it is necessary to take a wider societal viewpoint in measuring the costs of capital financing. The opportunity cost is now society's opportunity cost either in national or international terms and it is necessary to explore the extent to which this may be different from the private opportunity cost.

Social opportunity costs

From the individual institution's point of view what is given up by proceeding with an educational media investment is pretty clear. Either the institution would have invested the funds elsewhere or it would have used the funds for current consumption rather than investment. In each case the value of the alternative is given by the private market rate of interest. In the first case the institution loses the interest it would have earned by investing elsewhere. In the second case the institution has a choice between consumption now and consumption later. For example it could have used the funds to provide present students with better-quality materials. By investing instead in educational media it is deciding to forego this immediate benefit to produce better-quality materials to students in the future. Alternatively the funds could have been used to reduce students' fees in the present. Investing in educational media to reduce average costs will have the effect of reducing students' fees in the future. Thus the alternative is between immediate benefits and future benefits. Investing in educational media means giving up some present benefit, and the cost of doing this is measured by the rate of interest.

The institution here is no different from the private individual who with a given sum of money has to decide how much he will allocate to consumption and how much to saving and investment. Saving thus becomes deferred consumption, and the individual is assumed to require an incentive before he will undertake such saving. He tends to prefer consumption now to consumption in the future and requires a reward in the form of interest to change from one to the other. Thus the interest rate measures the preference of individuals for funds now to funds in the future – in other words their time preference. The higher the preference for funds now the higher will be the interest rate.[4]

But if it is a government that is making the investment decision, matters are a little more complicated. For a government is presumed to view matters not from an individual's or a particular group's perspective but from the standpoint of society as a whole.[5] In this situation society also has the alternative of another investment project or increased present consumption but the market rate of interest may now not be appropriate.[6]

Suppose that the only alternative to investing in the educational media project is to increase consumption. In practice this can only occur if a political decision to this effect has been taken. For otherwise the alternative to the project might be another investment project in the private or public sector. In the circumstances of consumption being the only alternative the relevant criterion for judging between public investment and public consumption is the social time-preference rate just as the relevant criterion for judging between private investment and private consumption was seen to be the private time-preference rate – the market rate of interest.

It is important, therefore, to ascertain whether there is any distinction between social and private time-preference rates; for if there is not, the market rate of interest can be used to measure the cost of capital from society's point of view. However, it can be argued on a number of grounds that the social time-preference rate is different from and lower than the private rate.

First there is the question of taxation. To earn a 10 per cent post-tax private rate of return with (say) a 33⅓ per cent tax rate requires a pre-tax return of 15 per cent. More generally the marginal rate of profits or income tax will measure the minimum difference between social and private time-preference rates.

This figure is a minimum because there may be other reasons why the private time-preference rate will be above the social rate. Market rates of interest can vary widely according to the borrower and the nature of the project. This is primarily related to uncertainty and it can be justifiably argued that there is less uncertainty in a project from society's point of view.

Finally it can be argued that the social rate is below the private rate because society as a whole puts a higher valuation on the future in relation to the present than do private individuals and is thus more willing to give up present consumption. Pigou (1932) argued that individuals were more concerned with their own welfare than that of future generations and that a specific role of government is to look after the welfare of future unborn generations. Marglin (1963b) puts it differently by arguing that there is a positive social benefit to providing for future generations which is over and above the private benefits which an individual gets through providing for his own children.

The quantitative importance of this third factor is very much a subjective matter and although suggestions have been made relating to its calculation (see Marglin, 1963a), it is difficult to incorporate it into an estimate of the social time-preference rate for a particular economy. The first two factors are a little easier for they imply that the private rate of return must be adjusted to allow for taxation and less uncertainty in social investment. Thus the social time-preference rate might be given by the post-tax rate of interest on long-term government bonds.

Thus if the alternative to the education media investment is increased present consumption then the social time-preference rate should be used. Where the alternative is increased investment, however, the market rate of interest is more appropriate. For the opportunity cost in this situation is what the funds could have earned through this alternative investment. The tax position and uncertainty factor are not relevant. Suppose for example that the pre-tax rate of return in the market is 15 per cent, that the tax on investment income is 33⅓ per cent and that the allowance for uncertainty is 2 per cent. The post-tax rate on long-term government bonds is then 8 per cent compared to the 15 per cent pre-tax private market rate of interest. If the only alternative to the educational media investment is consumption then the 8 per cent rate is appropriate. However, where 15 per cent can be earned on an alternative investment this is the appropriate rate. The whole of this 15 per cent would accrue to society through the benefits of higher-risk investment and the tax received.

It is likley, however, given the manner in which the public investment is financed, that the alternative will be a mixture of increased consumption and increased investment; for if the finance comes out of general taxation this is likely to reduce personal consumption and personal and corporate savings. The appropriate figures here would be a mix of the social and private time-preference rates weighted according to the assumed proportion of consumption and investment foregone.

This discussion may seem rather esoteric and academic. Yet to a society considering a multi-million dollar investment in educational media it is of crucial importance. The difference between the social and private rates of interest can be quite large and in the context of the size of projects concerned very significant. As Table 6.1 indicates taking a 10-year life the difference between 10 per cent and 15 per cent rate of interest on a million dollar investment is some $36 000 dollars a year or $360 000 over the project life.

An interesting question arises when it is claimed that no alternative exists. If this is the case then strictly speaking no interest should be charged because there is no interest to be gained by investing elsewhere. However this is unlikely because as has been pointed out bank deposit accounts are always likely to be available. In any event even if there is no other investment alternative there is always a choice between spending on the only investment project available or on some item of consumption. For example instead of investing in an audio-visual system the money could all be dispersed to students as extra pocket money during the year in question. If there is a preference for that rather than for the audio-visual system then there is a cost to using the funds for the latter purpose. The rate of interest in this case measures the preference for current consumption rather than future consumption resulting from investment.

Curiously enough the budgeting procedure of national or international agencies can bias them in favour of taking a private rather than a social viewpoint. Frequently an agency's funds are allocated on a year-to-year basis with any funds remaining at the end of the year being lost. From the agency's point of view as the year-end approaches there may be no alternative to investing in a particular project; for if the investment does not take place the funds are irretrievably lost. From the agency's private viewpoint it may be correct to charge no interest cost on these funds because there is no alternative. From the wider society viewpoint there is an alternative. The funds are not lost but are saved. Indeed perversely there may be a negative effect to not spending from the agency's private viewpoint if future years' budgets are based on previous year's actual spending. For under-spending in one year will now have a negative effect on future years' spending. The private cost of investment in this situation is actually negative and it may be in the agency's long-term interest to actually pay institutions to take funds from them!

7 Costs and Effectiveness Analysis in Practice

7.1 INTRODUCTION

The increasing interest in instructional media systems over the past decade has produced a number of case studies of both the costs and educational benefits of particular systems. Some of these have been more widely published (see, for example, Jamison *et al.*, 1976; Jamison and McAnany 1978) and provide useful information for comparative purposes.

It has been suggested that these results, particularly on the costs side, be collated and summarised to provide a guide to intending media users on the likely order of costs. Whilst any guidance might be welcome in a largely unknown area such an attempt is more likely to mislead. First media systems are diverse rather than unified. Their component parts are different in each system. The mix of audio, visual and written elements is usually unique to each system and systems are not picked off the shelf – at least if they are they should not be because it is clear from what has been written earlier that the starting point for any decision about media use is the educational task, not the media available. Given that educational tasks in different countries are likely to be different it is unlikely that a media system used in one country can be transferred as a package to another. As a result the costs implications of one package will only be of limited use as guidance for a different package.

A second limitation to the usefulness of cost studies of particular systems is that often different methodologies are used. The studies may have been undertaken for different reasons. Some may have been initiated by the providers of the system for internal management or propaganda purposes; others may have come from fund providers anxious to monitor the use of their funds; and yet other studies may have been initiated by academics or researchers for their own purposes.

Agencies such as the World Bank have attempted to overcome these methodological objections by standardising a number of different studies through the application of the same methodological principles. This has certainly improved the usefulness of these studies and the efforts should not go unrecognised, but it is doubtful if the results offer any practical guide to future users on the costs of their own system.

A final objection to the comparative approach is the different times at which the studies were undertaken. It is not easy to compare the results of a study at the beginning of a decade with one at the end. This is not just a matter of different prices – because it is possible to allow for inflation and standardise to a common price level – the problem is that with rapid technology changes, prices in one period are not a useful guide to prices in a subsequent period. For example a system relying on video recorders in the 1980s is likely to find itself facing radically different (i.e. cheaper) prices from any system using such recorders in the 1970s.

So what then is the value of empirical studies to future users? There are many. Despite the criticisms outlined above, studying other systems may still offer many useful insights. Most important it is not the results that should be studied but the factors that brought those results about. On the costs side what decision-makers should be looking at is the methodology (how costs analysis provides insights into the costs nature of the activity, and the reasons why costs per student are so low or high). Is the system maximising its output? Does it have a high ratio of fixed to variable cost? Is it able to respond flexibly to demand changes and so on?

On the effectiveness side, similarly the manner in which educational benefit is judged is important and the factors which made for success or failure rather than the fact of that success or failure should be studied.

The studies discussed in this chapter have been chosen with these objectives in mind. They cover different types of media use but the results are not claimed to be typical of each particular type. Rather the methodologies of the studies, the factors they identify, and the problems they uncover will, it is argued, be of more value to students of media use in education than the results themselves.

The Open University in the UK has pride of place for a number of reasons. It has aroused a great deal of interest and imitation since its establishment some 10 years ago. It is an example of a genuine multi-media system, and studies are available of both its costs and benefits. The SURGE project in Colorado has been chosen as an example of a videotape system, designed to bring on-campus material to off-campus students and to show the value of cost analysis as an input to on-going decisions about the development of a project. The PLATO system in the USA is a well-known advanced computer-assisted learning project and the study particularly on the costs side shows the implications of too optimistic a forecast of student usage. The Mexican Telesecundaria project is chosen as an example of a television-based system whose costs and effectiveness have been well documented, and the same can be said for the Nicaragua Radio Mathematics project which, as its name implies, is an example of a radio-based project. In both cases the analysis on the costs side particularly helps to indicate their financial strengths and weaknesses.

7.2 THE OPEN UNIVERSITY

The UK Open University is undoubtedly the largest example of the application of educational media to higher education. Established in 1969, and taking its first students in 1971, by 1976 it was incurring an annual recurrent expenditure of some £26 million ($45 million at the 1976 exchange rate) on a total student population of about 50 000.

Many aspects of the Open University have attracted attention. Some are interested in the fact that it caters for mature students allowing those over 21 a second, or in reality a first, chance to experience higher education. Others are interested in the open admissions policy with no academic prerequisites laid down for entry.

The major focus of attention, however, has been on the technology or learning system which the Open University has adopted to enable it to meet its educational objective of providing part-time higher education to unqualified mature students. This objective required the establishment of a distance learning system which consists of five main components: correspondence materials, television and radio programmes, class tuition at local study centres, and summer schools.

The correspondence materials are at the centre of the learning system taking up the largest proportion of staff time in preparation and student time in learning. For each course a package of materials is sent to students regularly throughout the year. This package contains a high-quality course unit text for home study during the prescribed period, as well as supplementary notes offering guidance to the reading of set textbooks, possible additional readings, introductory notes to the scheduled radio and television programmes for that period, self-assignment questions to enable students to monitor their progress during their reading of the course material, and assessment questions, both of multiple-choice and essay type, to be sent away for marking and which count towards the student's final grade. In addition students on science- and technology-oriented courses also receive home experimental kits, which as the name implies include materials and equipment which allows students to carry out relevant experiments in their home.[1]

The radio and television programmes are perhaps the most glamorous aspect of the Open University in that they are transmitted over BBC national networks and are thus available to any viewer or listener. However they form only a small part of the teaching package with most full credit courses consisting of between 11 and 16 25-minute television programmes and 20-minute radio programmes. As students are scheduled to spend somewhere in the region of 360 hours a year on a full credit course, even allowing for each programme to be watched twice means that only 24 of these hours, or some 7 per cent, is spent watching the programmes.

The face-to-face tuition is also a small part of the total system and varies between courses. Its purpose is to provide both personal and academic support to students in their own particular locality through the provision of part-time tutors, usually academics from other institutions, using the facilities of local colleges in the evenings and at weekends. The maximum personal tuition help is provided in foundation courses and amounts to about 1–2 hours a week. On other courses personal tuition amounts to between 10 and 16 hours spread over the year.

The summer school facility is another aspect of personal tuition but this time concentrated in a week's intensive study on a conventionel university campus during the summer months. Not all courses have summer schools, the emphasis being on all foundation courses, science and technology courses requiring intensive experimental sessions and arts courses requiring student interaction and participation.

The Open University is divided into six faculties: arts, social sciences, education, maths, science and technology. Each faculty, except education, has a foundation course and a range of second-, third-, and fourth-level courses divided into half or full credits.[2] To obtain an ordinary degree a student must obtain six credits including two at foundation level. An honours degree requires eight credits of which at least two must be obtained at third or fourth level. Students with previous qualifications are given credit exemptions up to a maximum of three for students with a previous degree.

This teaching system results in a high fixed cost in relation to student numbers. Virtually all the costs of television and radio programmes are incurred irrespective of the number of students. The some holds for the correspondence material, where the major academic staff costs of preparation are fixed and only the actual printing costs vary with student numbers. Even with the latter a proportion of printing costs, the setting of type for example, is also fixed.

In a major study of early Open University costs Laidlaw and Layard (1974) produced two cost functions to cover those costs which might be allocated to the production of courses and those which might be regarded as central university costs. Within these two categories the cost function distinguished between:

(*a*) fixed course costs, i.e. costs which are inescapable if a course is put on;
(*b*) variable course costs, i.e. costs which can be altered by altering the number of students on a course;
(*c*) fixed university costs, i.e. costs which are inescapable if the University is in existence;
(*d*) variable costs, i.e. costs which can be altered by altering the number of students in the University.

All costs in 1972 were allocated to one of these four headings. Thus fixed course costs included those of central academic staff, fixed printing and broadcasting. Variable course costs included variable printing and personal tuition and examination costs together with the costs of summer school and home experimental kits. Fixed University costs included a large part of the central administration and, for example, the cost of broadcasts not related to courses. Variable Univeristy costs consisted largely of regional costs on administration and counselling.

Laidlaw and Layard compared the figures with those obtained for conventional universities in the UK, and the results are most useful for comparative purposes. For central university costs they found that the Open University costs function was:

$$TCUC = £1\ 584\ 247 + 44n$$

whilst for a conventional university the function was

$$TCUC = £130\ 935 + 111n$$

where n is the number of students and $TCUC$ is Total Central University Costs, and figures are shown as 1971 prices.

The functions for course costs were separately calculated for each course then in production and the results are shown in Table 7.1. Whilst the Open University figures are calculated separately for each course the conventional university figures are only available for the subject area as a whole. Nevertheless the data in the first four columns of the table show clearly how in all the courses bar one the Open University has a higher fixed cost and lower variable cost than the campus university.

Although the data must be treated with circumspection they do yield some interesting results. By comparing the two cost functions for different levels

TABLE 7.1 Open University (OU) course costs and course costs in campus universities £ (1971 prices)

OU courses			Campus courses				
OU courses	*Overhead per full-credit course (1)*	*Variable cost per student full-credit course (2)*	*Campus university departments*	*Overhead per full-credit course (3)*	*Variable cost per student full-credit course (4)*	*Breakeven number of students per annum (5)*	*Actual OU students 1972 (6)*
A100	162 558	56	Arts	401	117	2 658	5 399
D100	147 579	51	Social science	671	87	4 080	6 586
M100	163 859	57	Mathematics	671	88	5 425	3 803
S100	181 158	89	Physics/Biology	666	218	1 398	3 596
T100	147 488	78	Engineering	673	223	1 013	3 354
A201	78 081	28	Arts	401	117	872	1 623
A202	80 305	26	Arts	401	117	878	1 711
D203	72 590	33	Social science	671	87	1 332	1 064
M201	108 442	56	Mathematics	671	88	3 367	1 448

D281	73 702	109	Social science	671	87		283
D282	66 858	46	Social science	671	87	1 614	430
D283	70 356	32	Social science	671	87	1 267	1 684
E281	83 378	31	Social science	671	87	1 477	3 680
E282	84 966	28	Social science	671	87	1 429	2 596
E283	78 016	32	Social science	671	87	1 406	3 030
MST281	106 622	57	Mathematics	671	88	3 417	747
MST	104 856	38	Mathematics	671	88	2 084	913
SDT286	109 314	70	Physics/Biology	666	218	734	1 634
TS282	115 786	158	Engineering	673	223	1 770	1 232
S22-	95 007	100	Physics/Biology	666	218	800	636
S23-	116 889	101	Physics/Biology	666	218	993	533
S24-	100 146	138	Physics/Biology	666	218	1 244	389
S25-	98 070	180	Physics/Biology	666	218	2 563	229
S2-1	110 490	95	Physics/Biology	666	218	893	556
S2-2	122 742	78	Physics/Biology	666	218	872	448
S2-3	151 638	57	Physics/Biology	666	218	[illegible]	763

Sources: (*a*) OU data.
(*b*) Campus universities, Layard and Verry, Table 12 (1968/9 prices adjusted to 1971 prices using the Brown index).

of student numbers Laidlaw and Layard (1974) calculate the break-even number, i.e. that number of students above which total costs at the Open University are lower. For central university costs the breakeven number of students is 21 691 whilst the figures for course costs are shown in column 5 of Table 7.1 with actual course numbers in 1972 shown in column 6.

The figures show that with 50 000 students the Open Univerisity reaps substantial economies of scale on central costs but that on about half of the courses conventional university course costs are lower. Nevertheless overall the Open University, by having such high student numbers, is able to spread its fixed costs sufficiently to produce what Wagner (1977) calculates to be about a 4 : 1 advantage over conventional universities in the average recurrent cost per undergraduate, i.e. Open University average costs are a quarter of those of conventional universities.

In his 1977 paper Wagner updates some earlier calculations he made comparing Open University and conventional universities. Besides the average costs calculation just referred to he also calculates on the basis of experience on students failing to complete a course that the average cost per honours graduate at the Open University is likely to be about half that of a graduate of a conventional university. However Wagner also takes into account opportunity costs in his calculations. An important element here is the part-time nature of Open University students which allows them to continue working whilst studying. Most conventional university students, in contrast, are full-time and society loses the output they could be producing whilst studying. If these opportunity or resource cost differences are taken into account then the average cost per undergraduate difference between the two systems is in the region of 7 : 1 in the Open University's favour.

Now whilst these results are of interest they are of only limited value as they depend on the actual conditions of operation of the Open University in the UK. They do not offer much guidance about the operation of the University under different conditions or circumstances. However as a major part of his 1977 paper Wagner builds on the approach of Laidlaw and Layard (1974) in establishing a costs function that enables the implications of alternative developments to be spelt out.

The costs function attempts a simple disaggregation of the output variables. It identifies three main outputs or activities that give rise to additional costs. These are the production of new courses, the maintenance of existing courses and the enrolment of students. The output variables are interdependent only in the sense that a new course in year t will mean an additional course to be maintained from year $t + 1$ onwards. Otherwise it is possible to increase student numbers without increasing the number of new and maintained courses and vice versa. Thus the costs function reads

$$TC = a + bCn + xCm + ySn$$

Where TC = total costs
Cn = number of new courses
Cm = number of maintained courses
Sn = number of students
a = fixed costs
b, x and y = appropriate coefficients of Cn, Cm and Sn.

This function can now be used to assess the cost implications of alternative policies. For example in 1976 the Open University was maintaining some 55 full credit equivalent courses for the benefit of some 50 000 students. Costs in future years will be determined by how many new courses are produced and how many new students are enrolled. It is necessary therefore to estimate the marginal costs b, x, and y of respectively putting on a new course, maintaining a course and enrolling a new student all other costs being regarded as fixed.

Based on an investigation of Open University costs Wagner estimates that the appropriate coefficients (in 1976 £s) are:

$$TC = 19\ 824\ 000 + 436\ 000\ Cn + 44\ 000\ Cm + 200\ Sn.$$

In other words it is estimated that each new course costs £436 000 to produce, each existing course costs £44 000 to maintain and each new student costs £200 per annum, all other costs amounting to £19 824 000.

Starting from this base it is possible to predict future Open University costs on the basis of known plans as well as analyse the effect of alternative assumptions. Table 7.2 provides Open University plans in 1976 up to 1979.

TABLE 7.2 Open University plans 1976–79

Year (1)	*New courses produced* (2)	*Net new courses ((2)−replacement courses)* (3)	*Courses maintained* (4)	*Student numbers* (5)
1976	9	7.5	55.16	50 994
1977	13	9.5	62.16	56 550
1978	12	5	72.16	60 500
1979	12	4	77.16	62 500

It will be noted that not all new courses add to the number of courses which require maintaining in subsequent years as some of these new courses may simply be replacing existing courses. The results of these assumptions are shown in Table 7.3, and the main conclusion is that little reduction in

TABLE 7.3 Open University average cost per student 1976–79 (£000, 1976 prises)

Year	*Fixed cost*	*New course costs*	*Maintained course costs*	*New student costs*	*Total costs*	*Average cost per student*
1976	19 824	3 924	2 427	–	26 200	0.513
1977	19 824	5 668	2 757	1 111	29 400	0.520
1978	19 824	5 232	3 175	1 901	30 100	0.498
1979	19 824	5 232	3 395	2 301	30 800	0.493

average costs was expected in the period to 1979. The economies of scale reaped by the University in the earlier years, as shown by the 4 : 1 average cost per student advantage, has now stopped and it seems to be following the conventional university pattern of little increase in productivity.

One reason for this is that the increase in student numbers has slowed down. On the other hand it may well be that a figure of about 65 000 students is the maximum the present system of production and administration can handle and any increase above this figure would require radical reorganisation and a rise in the element of cost now regarded as fixed. Moreover at the 1979 level of expenditure for course production and maintenance student numbers would have to rise to nearly 90 000 to bring average costs down to £400 per annum.

The main reason why average costs show little reduction since 1976 (and indeed since 1973) is that the Open University has been using the economies produced by rising student numbers to increase the number of courses offered to students rather than to reduce average costs. However as the increase in student numbers flattens out in the latter part of the decade the scope for economies to be used in this way is limited. As Table 7.2 indicates the number of net new courses added to the programme was planned to fall significantly in 1978 and 1979.

The costs function shows in fact how average costs could be reduced simply by increasing student numbers without increasing the number of new courses. If in 1979 the planned number of students were presented with the 1976 number of new and maintained courses average costs would be reduced to about £450 per student.

One limitation of the costs function is that the data are based on existing policies. In the latter part of his paper, however, Wagner considers the adoption of the function to study the effects of alternative policies. One alternative is to change the mix between different faculties giving greater emphasis to subjects with lower marginal costs in production and maintenance. For example whilst the average cost of producing a new course in the University as a whole is £436 000 the cost in different faculties varies between £340 000 in arts and £598 000 in science. In addition science and technology students impose higher costs in the student-related areas because of home experimental kits and summer schools.

Thus in broad terms every switch from science and technology to arts and social science courses is estimated to save the University at least £200 000 in new course production costs, £20 000 in maintenance costs, and about £60 per student per annum for every student taking the course. Wagner estimates that if all courses in 1976 had been in arts and social sciences average costs in that year would have been £426 per student and not £493, producing a saving on total expenditure of some £3.5 million.

Another way to reduce costs is to change the components of the University's teaching system. For example Wagner calculates that if all broadcasting were removed fixed costs would be reduced by £2 million or nearly 30 per cent and costs per course by £115 000 per new course and £11 500 per maintained course, a fall of some 25 per cent. If there had been no broadcasting in 1976 the average cost per student would have been £440. Alternative options are available such as an reduction in part-time tutoring or summer school attendance or a deterioration in the quality of printing and presentation of the course materials. It is a legitimate argument against these options, however, that they would change the nature of the product offered to the students and clearly an Open University operating under such circumstances would be different from the present one.

However this indicates that the actual average cost per student figure at the Open University is a consequence of decisions taken early in the University's life about the mix of the teaching components, and offers little guidance on the cost effects of alternative Open University type systems in different circumstances. An Open University type technology can be made more or less expensive than the figures resulting from the particular production components of the existing Open University. Increasing the number of courses, broadcast programmes and hours of part-time tuition will raise costs. Reducing these elements will cause costs to fall. It is therefore possible to make an Open University system as cheap or as expensive as the planners wish.

The value of cost functions as shown here is that they can help decision-makers in the institution itself to see the cost implications of alternative policies. Moreover they indicate to outside observers not just the final answers on cost comparisons which, as just observed, are of limited value but the structure of costs which produces these final answers.

7.3 VIDEO-TAPE SYSTEM OF SURGE

SURGE[3] stands for State University Resources for Graduate Education and was established in 1967 by the College of Engineering of Colorado State University to provide graduate-level work to employees of various corporations in the State of Colorado without the necessity of their attending the campus of the University. The system expanded and by 1972–73 the University offered master degree programmes in Civil, Electrical, Mechanical, and Industrial Engineering, and Business Administration as well as individual courses in mathematics, statistics, atmospheric science, psychology and watershed science. In that year 80 different courses were offered and these were taken by 1277 off-campus students from 34 different industrial and governmental organisations.

The SURGE programme makes available to off-campus students courses which are already in existence for campus students. This is done by videotaping a lecture plus any classroom discussion in a specially equipped studio classroom. The tape is packaged with class materials, assignments and examinations and collected by a commercial delivery service in the evening of the same day. It is then delivered to the appropriate industrial location where it is usually viewed by off-campus students within 48 hours of the original lecture. During the viewing session a graduate student is usually on call at the University to deal with any telephone queries students may have as they watch the material. The tapes can be held for a second viewing but eventually they are returned to the University where they are wiped and used to record subsequent lectures. Personal contact with students is maintained by regular staff visits to their location.

SURGE students have to complete the same assignments, reports and examinations as on-campus students. If there is any laboratory work they use the facilities of their employer. When specialised reading is required, the article is photo-copied and sent to each student. SURGE students receive the same certificate and notation as campus students and no distinction is made between them in the records.

The participating organisations provide the classroom facilities, playback equipment and administrative support for the programme free of charge to the University. All parties benefit from this arrangement. The University has certain costs of the project met from outside its own budget whilst the project as a whole provides an additional source of demand. The organisations which participate obtain in-service training and better qualifications for their employees at a lower cost than if they had to attend on campus, whilst the students themselves obtain these qualifications without having to give up their employment to attend full-time or travel long distances to study part-time.

There has been little formal evaluation of the educational benefits of the SURGE project. During its first 3 years of existence Colorado State University conducted its own evaluation and concluded that 'students in the remote classes were attaining levels of achievement equal to that of the on-campus students' (Baldwin *et al.*, 1972).

Cost analysis

In analysing the costs of the SURGE system Wagner (1975) produced disaggregated cost functions which enabled the effect of changing different variables in the system to be assessed. The total cost of the programme in any one year is made up of the cost of recording lectures, duplicating and distributing them and providing student services and support at each location. So:

$$TC = f\,(R.\ D.\ S) \qquad (1)$$

where TC = total costs
R = recording costs
D = duplicating costs
S = servicing costs.

Recording costs have a large fixed element in that the studio–classroom and supporting staff are required if only 1 hour's worth of material is recorded per annum. These costs will not vary as the classroom is more heavily utilised until a certain maximum number of hours is reached. Then a new studio–classroom will be required. In addition, there are variable costs which are directly related to each hour's worth of recording. Thus the recording cost function is:

$$R = a + bh \qquad (2)$$

where a = fixed costs
h = course hours recorded
b = variable cost per course hour recorded

and

$$ACR\ \frac{R}{h} = \frac{a}{h} + b \qquad (3)$$

where ACR = average costs of recording 1 hour of course material.

Duplicating and distribution costs depend on the number of locations to which each hour's worth of course material has to be sent. Each location requires a separate recording because the speed of the operation does not allow time for copies to be made from the master tape. So a sufficient number of recording machines must be available to cover the number of locations each course is likely to be sent to. The cost of the recording machines is, however, fixed in relation to the number of recording hours. The other costs such as distribution depend on both the number of locations (or tapes required) and the number of hours of course material produced per annum. Thus duplicating and distribution costs can be represented in the following function:

$$D = xl + yht \qquad (4)$$

where x = cost of recording equipment
l = maximum number of locations per course
y = other duplicating costs per location.
h = number of hours recorded
t = average number of locations per course.

$$AC_D = \frac{D}{h} = \frac{xl}{h} + yt \qquad (5)$$

where AC_D = average cost of duplicating and distributing one hour's worth of course material.

Finally, there are servicing costs. These consist of faculty visits to students which depend on the number of locations per course and course hours and the cost of graduate instructors' help in being available for personal calls from off-campus locations whilst the students are watching the material. These, together with secretarial and other minor student support expenses, can be viewed as fixed costs for each course hour. Thus servicing costs can be represented as:

$$S = zth + ch \qquad (6)$$

where z = cost of faculty visits per location per course
t = the average number of locations per course
c = fixed costs of student support per hour of course material

$$AC_S = \frac{S}{h} = zt + c \qquad (7)$$

where AC_S = average cost of providing student support per hour of course material.

$$AC = \frac{TC}{h} = \frac{a}{h} + b + \frac{xl}{h} + yt + zt + c \qquad (8)$$

$$= \frac{a + xl}{h} + (z+y)t + b + c. \qquad (9)$$

Finally, the average cost per student contact hour can be presented as:

$$\frac{AC}{S} = \frac{\dfrac{a + xl}{h} + (z + y)t + b + c}{S}. \qquad (10)$$

This is the generalised cost function for the SURGE programme which enables the effect of changing the number of hours, students, average and maximum locations per course to be measured.

Wagner calculated the following values for each of these functions in 1972 dollar prices:

Recording cost
44 340 + 3.95 *h* if one studio was in operating.
66 980 + 3.95 *h* if two studios were in operation.

Duplication and distribution costs
320 *l* + 3.20 *ht*.

Servicing costs
1.25 *ht* × 18 *h*.

These can be combined to produce a total cost function as follows:

44 340 + 21.95 *h* + 4.45 *ht* + 320 *l* for one studio–classroom
or 66 980 + 21.95 *h* + 4.45 *ht* + 320 *l* for two studio–classrooms
or 89 620 + 21.95 *h* + 4.45 *ht* + 320 *l* for three studio–classrooms.

The average cost per hour of course materials is obtained by dividing through by *h* while the average cost per student contact hour is obtained by further dividing through by the average number of students per course *S*.

Thus in 1972/73 when three studio classrooms were in operation the average cost per student contact hour was given by the function

$$\frac{\dfrac{89620 + 320\,l}{h} + 4.45\,t + 21.95}{S}.$$

In 1972/73 there were 2790 hours of recorded material (h), the maximum number of locations for any one course (L) was 11, the average number of locations per course (t) was 2.92 and the average number of students per course (S) was 12.11. Thus the average cost per student contact hour was given by:

$$\frac{\dfrac{89620 + 320(11)}{2790} + 4.45\,(2.92) + 21.95}{12.11}$$

$$= \frac{33.38 + 12.99 + 21.95}{12.11} = \frac{68.32}{12.11} = \$5.64.$$

However, because of the manner in which the costs function has been formulated it is possible to trace the effect of changing the key variables. For example the three studio–classrooms were being used for 2790 hours. The effect of increasing this utilisation is shown in Table 7.4. Even if utilisation was increased to some 1200 hours a year for each classroom, which means 30 hours a week for 40 weeks of the year, the average cost per student contact hour would only fall to $5.02.

TABLE 7.4 Effect of increasing course hours

h	$\frac{93\ 140}{h}$	$\frac{AC}{S^*}$
2400	38.81	6.09
2500	37.26	5.96
2600	35.82	5.84
2700	34.50	5.73
2800	33.26	5.63
2900	32.12	5.54
3000	31.05	5.45
3100	30.05	5.37
3200	29.11	5.29
3300	28.22	5.22
3400	27.39	5.15
3500	26.61	5.08
3600	25.87	5.02

$^*S = 12.11$.

Of greater significance are changes in the average number of students per course and average number of locations per course, as Table 7.5 shows. Whilst the actual average cost per student hour figure of $5.64 already shows the benefits of economies of scale compared with what it might be if the system was severely under-utilised it is clear that further reductions in average cost are still possible. Indeed if one extra location could be found for each course even if this resulted in only one extra student per course then average costs would fall. For example with three locations and 12 students average cost is $5.72. With four locations and 13 students average costs fall to $5.63.

TABLE 7.5 Effect of varying student numbers per course and location per course

S/l	*1*	*2*	*2.92**	*3*	*4*	*5*
1	59.78	64.23	68.32	68.68	73.13	77.58
2	29.89	32.12	34.16	34.34	36.57	38.79
3	19.92	21.41	22.77	22.89	24.38	25.86
4	14.95	16.06	17.08	17.17	18.28	19.40
5	11.96	12.85	13.66	13.74	14.63	15.52
6	9.96	10.71	11.39	11.45	12.19	12.93
7	8.54	9.18	9.76	9.81	10.45	11.08
8	7.47	8.03	8.54	8.59	9.14	9.70
9	6.64	7.14	7.59	7.63	8.13	8.62
10	5.98	6.42	6.83	6.87	7.31	7.76
11	5.43	5.84	6.21	6.24	6.65	7.05
12	4.98	5.35	5.69	5.72	6.09	6.47
12.11*	4.94	5.30	**5.64**	5.67	6.04	6.41
13	4.60	4.94	5.26	5.28	5.63	5.97
14	4.27	4.59	4.88	4.91	5.22	5.54
15	3.99	4.28	4.55	4.58	4.88	5.17
16	3.74	4.01	4.27	4.29	4.57	4.85
17	3.52	3.78	4.02	4.04	4.30	4.56
18	3.32	3.57	3.80	3.82	4.06	4.31

* Actual numbers in 1972–73.
s = students per course.
l = locations per course.

7.4 COMPUTER-ASSISTED INSTRUCTION THROUGH PLATO

PLATO stands for Programmed Logic for Automatic Teaching Operations and is an attempt to provide a complex and sophisticated computer-based education system. It began in 1959 at the University of Illinois and has undergone a number of developments so that the latest model is PLATO IV.

A simple use of the computer is to perform routine drill and practice tasks, particularly in the field of arithmetic and reading for elementary school children. This is basically an automated version of a programmed text. The student is faced with a series of questions and the computer is programmed to accept certain answers and reject others. PLATO I, established in 1959, had this capacity, but developments through the 1960s on PLATO II and III produced much more flexible teaching strategies for use in fields as diverse as algebra, anatomy, psychology, pharmacology, languages and life sciences.

In an attempt to explain the versatility of PLATO, Alpert and Bitzer (1970) dealt with a number of misconceptions about computer-based education and related these to the potentialities of the PLATO system. The first misconception is the one outlined in the previous paragraph, namely that computer-based education is synonymous with programmed instruction. Alpert and Bitzer argue that

> the interchange of factual information between man and the computer is only one mode whereby a teaching strategy may be incorporated into the computer. For example, the information may be stored in the machine in the form of simulated models of an actual system or device; one may simulate such widely differing systems as the human circulatory system or a defective television set. Through a set of instructions stored in the computer, so-called algorithms, the computer is called upon to calculate unique responses to varying student inquiries.

In other words the computer is not programmed to accept a single correct answer. It is programmed to think for itself through an algorithmic approach so that it can respond to student inquiries by asking itself a number of questions about the answer before responding to it. In PLATO IV, for example, programmes can be written which enable the computer to distinguish between an incorrect or nonsense answer and a spelling mistake. The computer is able to respond to unpredicted behaviour.

This approach is developed by Alpert and Bitzer in dealing with the second misconception, namely that the computer must be programmed to anticipate all conceivable student responses so as to compare them with 'correct' answers stored in the machine. Alpert and Bitzer argue that

> teaching strategies which do not call for specified student responses are widely used. . . . For example geometry students may be called upon to 'draw' on the PLATO graphic display a figure that has specified geometrical properties but need not be of a particular size or in any given

location on the screen. In such cases a set of algorithms in a so-called 'judging routine' makes use of the computational power of the machine to assess the validity of the 'answer'.

A third misconception which Alpert and Bitzer try to dispel is the view that computer-based instruction cannot develop critical thinking or analytical skills in students. They argue that on the contrary it 'has often been found to be more effective than standard educational procedures in many learning situations that call for judgement, interpretation of complex problems and evaluation by the student of the validity of the conjectures'. They cite an example of the 'inquiry' mode of instruction, where the student is confronted with a problem which cannot be answered by multiple choice. He may need to ask the computer some questions or ask it to perform various tests or to provide him with some information necessary for solving the problem. The computer can respond to these requests, query their relevance, suggest further avenues of inquiry and assess the final result.

The versatility of PLATO IV is shown by the following examples from science instruction. In biology simulation techniques are used in a genetics course to teach students the laws of inheritance. This is achieved through a series of fruit-fly matings. Each student is presented on a plasma display panel with a group of parent flies to examine. The total stock will contain flies with normal and mutant characteristics. These are assembled by the computer from individual parts rather than the computer having a stock of pre-stored pictures. Any combination of normal and mutant characteristics can be assembled. The student chooses a mating and within seconds the offspring are shown. Further matings of these offspring can also be shown. Students keep a logbook of all their experiments so that tests of hypothesis can be undertaken and the results handed in as a formal laboratory report.

The actual experiment in the laboratory would take several months but requires 3–4 hours' work on the computer. In that time the student can perform the basic experiments of the Mendelian law of inheritance with each student setting up his own experiment. The off spring are generated by using random numbers and probabilities based on the laws of Mendelian genetics. This is one of 35 lessons in a beginner's course in genetics and evolution. All lesson material is given in 4 hour's work on the computer and is followed by a 2-hour weekly discussion period with a tutor.

A chemistry lesson is designed to train students to identify unknowns by formulating correct questions and interpreting the results. This is meant as a pre-laboratory exercise to train students in the correct intellectual approach before they undertake actual experiments. The language of the computer is natural and the student and computer engage in a question-and-answer interaction. The computer can give the student advice on where to find further information and the direction in which questions ought to go. It can distinguish between wrong answers and spelling mistakes. A student can often identify five or six unknowns in a matter of hours which might be equal to a whole term's work in a laboratory.

These two examples illustrate a little of the versatility of the PLATO system. In addition the plasma display panel with a grid of 512 × 512 dots allows graphical display, both static and dynamic. It can be activated by student touch, allowing the student to draw his own diagrams, graphs, etc. It can support a rear projection screen for colour slides or moving pictures and can be integrated with an audio-tape linked to the terminal.

The computer will keep records of each student's actions, requests and performance. It can provide individualised instruction, immediate feedback and remedial training by use of complex internal branching and the alteration of presentation or type of material based on the student's past performance. For a more comprehensive discussion of the capabilities of PLATO and its electronic properties see Bitzer *et al*. (1973).

The core of the PLATO IV system is the central computer which provides the logic, rapid-access memory and main data-processing facility for the system. The tasks required of it ensure the need for a very powerful (and expensive) computer. Linked to it is a software system for organising various teaching, testing or research strategies and for specifying the language in which directions to the computer are to be formulated.

The individual student terminal through which the student works has a keyset which the student uses to respond to questions from the computer and to give instructions and also a plasma display panel on which questions, instructions and visual images are shown. A distribution channel is required for carrying information between the computer and individual student terminals. A number of alternative models are available and indeed these have different cost implications (see Ball and Jamison, 1973). The optimum system depends on the number of terminals to be connected and the length and geographical nature of their dispersion. The PLATO system uses coaxial (television) lines from the central computer to various distribution centres and telephone lines from these centres to individual terminals.

These three items – computer hardware and software, student terminal, and distribution channel – constitute the core of a computer-based education system. In addition when costs are considered the management and instruction costs should be included. The components of the PLATO system are the hardware by which the interaction of education takes place. The costs of producing the content of that education and its management without which the hardware would be irrelevant, must also be considered.

In their analysis of PLATO IV costs Alpert and Bitzer calculated that the operational costs of the system would amount to $0.68 per student contact hour with a further $0.25 per student contact hour for instructional cost (i.e. authors and supportive services salaries plus materials, etc.). Thus the total cost per student contact hour was estimated to be below $1. It is assumed that these costs are in 1969 prices although no explicit statement to this affect was made.

Latest estimates of PLATO IV costs per student contact hour are nearer to $5. A small part of this might be explained by the rise in prices since 1969. However some of the items of cost, for example, the central computer, would not be affected by this factor. Part of the reason is an under-estimation of costs on certain items, particularly communication and curriculum costs. As indicated previously communication costs depend on the distance of the terminal from the central computer. PLATO IV has not been able to develop the communication system envisaged by Alpert and Bitzer and the alternatives are much more expensive. A leased line in the USA was costing in the region of $9 per annum per mile in the mid-1970s, implying a large communication cost for terminals some distance from the centre.

On curriculum costs Alpert and Bitzer assumed that the instructional cost of preparing 1 hour's worth of material would amount to about $600 on average. (They assumed that each hour's worth of material would be used by 500 students for 5 years which produced the instructional cost per student contact hour of 25 cents referred to above. We shall discuss the utilisation factor in a moment.) Observers of the PLATO IV system now believe this to be a serious under-estimate, although it is difficult to give a precise figure. It seems generally agreed, however, that the time, effort and cost required to produce an hour's instructional material is much greater than originally estimated.

These cost under-estimates, whilst important, would have had less effect on the per student contact hour figure if the utilisation rates envisaged originally had been realised. It is the over-estimation of student usage which is the main cause of the difference between original estimates and actual figures. Alpert and Bitzer assumed that the system would incorporate over 4000 terminals each of which would be used by students for an average of 2000 hours per year (45 weeks at 44 hours per week), producing an annual number of 8.2 million student contact hours.

However, the position in the mid-1970s looks very different. It is generally accepted now that the system is unlikely to be able to handle more than a maximum of 1000 students at any one time. Allowing for the need for some spare capacity, the maximum number of terminals installed is unlikely to be above 1250. The evidence on average terminal use is scanty and estimates range from 1200 hours to 2000 hours. Thus even if the maximum possible usage was to be achieved this would produce 2.5 million student contact hours rather than the 8.2 million previously forecast. Thus the non-achievement of the student contact hour target has the effect of raising the average cost by a factor of more than 3. It should also be noted that the figure of 2.5 million student contact hours is the new estimated *maximum*. Present utilisation rates are nowhere near even this revised target.

All this of course needs to be put into perspective. A costs study of the PLATO system is useful as an example of the effects of wrongly estimating costs and utilisation rates at the outset of a project. It may well be that the likely average cost per student contact hour figure of $5, whilst 5 to 6 times higher than the original figure, still makes the PLATO IV system attractive compared to other instructional systems including the live lecture. This may be the case particularly when some of the educational benefits of PLATO IV as outlined earlier are considered.

Moreover with many of the costs having been incurred already and being fixed in relation to student contact hours there is much to be said for pressing ahead and trying to increase utilisation to the maximum. The central computer costs are fixed. So are the curriculum costs of existing materials. The marginal costs of using an existing student terminal to follow an existing course are therefore very small. Increasing the number of terminals would of course incur extra terminal and communication costs but average costs would still fall even if each extra terminal was used for only 400 hours a year, or less than 10 hours a week, during term time. Starting from a lower number of terminals each extra terminal need only be used for 100 or 200 hours a year to reduce average costs. In these circumstances it will almost always pay to increase the number of terminals.

7.5 TELEVISION FOR SECONDARY EDUCATION: THE MEXICAN TELESECUNDARIA PROJECT

Introduction

One of the major educational problems facing Mexico is the lack of opportunity for secondary education facing many pupils. For example in 1965 about 37 per cent of primary-school graduates could not take their studies further and the problem was most acute in rural areas.

The Telesecundaria project was designed to overcome this problem and was first established on a small scale in 1966. 39 000 pupils were enrolled in the project through the three secondary grades, by 1972.

The main instructional medium is television and in a typical week students receive about 30 televised lessons divided amongst various subjects and vocational activities. Each lesson averages about 20 minutes of television programme with the remaining 40 minutes divided between preparation and follow-up activities supervised by classroom co-ordinators. The programmes are transmitted over one of the regular channels and thus can be received by other than enrolled pupils.

The pupils meet not in regular schools but in a variety of buildings. Often rooms are provided by the local municipality and occasionally by one of the pupils' families. Instead of qualified secondary-school teachers the Telesecundaria relies upon classroom co-ordinators to supervise instruction. These are drawn from the ranks of senior primary-school teachers and they instruct pupils over all the three secondary grades. Each month the co-ordinators receive an outline and schedule of the topics to be covered in each telelesson. In addition students purchase workbooks which help them with their classwork.

The television programmes are produced through the Audio-Visual Department of the Mexican Secretariat of Public Education. The television teachers and producers who are responsible for the development and presentation of broadcast lessons are recruited from the traditional school system and given special training.

The Telesecundaria system, whilst retaining the same curriculum and goals of the traditional Mexican secondary school system, uses television in combination with more familiar educational resources such as classroom teachers and textbooks to enable Mexico to extend secondary education to those sections of the population, particularly rural communities, whose size and isolation had previously prevented their attendance at regular schools. A number of investigators have reported on the project, in particular Klees (1975), Mayo *et al*. (1975) and Jamison *et al*. (1976). This analysis of the Telesecundaria is based on these reports and especially the last two named.

Cost Analysis

In their analysis of Telesecundaria costs Jamison *et al*. (1976) distinguish between the costs associated with programmes and other costs of the system such as classroom co-ordinators, workbooks, etc. This is justified on the grounds that the programmes' costs are the additional costs of Telesecundaria over and above the traditional system, and should be analysed separately.

Programme costs consist of production, transmission and reception costs and data for the period 1966–86 are shown in Table 7.6. Actual figures are shown up to 1972 and projections after this date are based on the assumption of a 5 per cent annual growth in student enrolment within the existing geographical area. The detailed assumptions for each of the cost items are explained in the footnotes to Table 7.6.

The data in the table can be used to calculate average cost from the perspective of any year over any given number of years or the *ACij*, as explained in the previous chapter. The actual figures will depend on the rates at which the capital costs shown in Table 7.6 are discounted. Jamison, *et al*. calculate *ACij* for three discount rates, 0, 7.5 and 15 per cent, and point out that over the 20-year period 1966–86 using a zero rather than a 15 per cent discount rate would under-state costs by some 30 per cent. The average cost from year 1966 to year 1986 at a discount rate of 7.5 per cent is shown in Table 7.7.

A calculation made at the start of the project on the basis of the data in Table 7.6 would have produced an annual average cost per student calculation of $23 over the lifetime of the project if it survived for 28 years. However if the project had been terminated after 4 years the annual average cost per student would have been about $60 over the project's life. From the perspective of the early 1970s when the early investment is considered as a bygone, the cost implications of continuing and the risk of so doing are far less. In 1973 if the project is continued even for just another year the average cost per student would only be $21.

The figures, however, only cover the programme costs of Telesecundaria. Table 7.8 provides data on the annual average cost per student of both the Telesecundaria and the traditional system in 1972. The footnotes to the table explain the basis of the figures, which is to calculate what it would cost the traditional system to bring secondary schooling to the rural areas covered by Telesecundaria. As the figures indicate, the traditional system would cost 65 per cent more to do the same job. In addition the Telesecundaria average costs could be reduced if more students were enrolled.

However on closer inspection it would seem that the whole of the costs advantage arises from the lower costs of providing classroom teachers in the Telesecundaria system. This is because in Mexico (at least at the time of the study) secondary-school teachers received more than double the salary of primary-school teachers. As the Telesecundaria teachers came from primary-grade teaching their costs were lower. Thus the Telesecundaria system is a very good example of using technology to substitute a low-resource cost for a high-resource one. By placing the main educational focus on the television programmes, the system is able to dispense with scarce expensive specialised secondary teachers substituting them with less expensive primary teachers.

Effectiveness

A number of different effectiveness measures were used. Cognitive achievement was measured by pre- and post-testing of a large sample of ninth-grade (third-year) secondary students in both the Telesecundaria and traditional systems in maths, Spanish and chemistry. The subjects were chosen because of their importance in the curriculum, and the third year was chosen because it was felt that the cumulative effect of exposure to the two different systems would by then be well established. The tests consisted of multiple-choice questions and the same test was given in both the pre- and post-examinations.

The cognitive tests were supplemented by a general ability test but administrative problems prevented this being given to pupils in the traditional system. The evaluation also covered students' aspirations and attitudes to the Telesecundaria, but they are not discussed here. A report on the findings can be found in Mayo *et al.* (1975) and Klees (1975).

On the cognitive tests, whilst both groups started at about the same level, the Telesecundaria group achieved a slightly higher learning gain in all three subjects. The ability tests were of limited use as a cross-reference because they were only administered to the Telesecundaria pupils, but when these results were analysed expert educational opinion in Mexico indicated that they were below the levels expected and achieved on past tests in the traditional schools.

An analysis of parental and home background of students indicated that the traditional student group rather than the Telesecundaria group had those characteristics in terms of parental income and education which would lead to an expectation of better performance.

It would seem reasonable to conclude, therefore, that whilst the background characteristics of Telesecundaria students and their general ability levels might lead to an expectation of lower performance than traditional students, they performed equally well if not better in the three subjects tested. As Mayo and co-workers put it:

> If background factors are positively related to achievement, why did the traditional student group, from more advantaged backgrounds, not do better than the Telesecundaria group on their achievement tests. The apparent answer is that the instructional television of Telesecundaria makes a difference in learning; a group from poorer homes, when given the chance to learn by instructional television and a classroom co-ordinator, can overcome the disadvantage and achieve equally with regular secondary students (Mayo *et al.* (1975), p. 215).

TABLE 7.6 Costs of the ITV Components of Telesecundaria and Utilization[a] (in thousands of 1972 US dollars)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Production																					
Facility	64	64																			
Equipment	162	162	60	60	60	60					102	102	29	29	29	29	29	29	29	29	29
Operations	108	228	337	444	444	444	444	444	444	444	444	444	444	444	444	444	444	444	444	444	444
Transmission																					
Operations			17	35	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
Reception																					
Equipment		1	85	109	122	61		12	24	24	12	24	24	24	24	24	24	36	24	36	24
Replacement							1	85	109	122	61	1	97	133	146	73	25	121	157	170	147
Maintenance and operations			9	20	32	38	38	39	41	43	44	46	48	50	52	54	56	60	62	66	68
Total costs	334	455	508	668	710	655	535	632	670	685	715	669	694	784	747	676	630	742	768	797	735
Number of students (in thousands)			7	16	26	31	29	30	32	34	35	37	39	41	43	45	47	50	52	55	57

The assumptions underlying the cost data presented are detailed below:

Production facility. This only includes the costs of the four television studios, as other production and administrative operations presently utilise excess space within the Audio Visual Department of SEP. There are four studios, constructed over a 2-year period, at a cost of $32 000 per studio, and they are assumed to have a 20-year life.

Production equipment. This includes the costs of studio equipment and videotapes. Studio equipment cost $204 000, was purchased in the 2 years prior to initial operation, and is assumed to have a 10-year life. The present stock of 1500 hour length videotapes, costing $240 per tape, was purchased over the first 6 years of the project. It is assumed that tapes are used once only, 10 per cent of the programming is taped (as was the case in 1972), and that after 12 years; when the present stock is exhausted, new tapes will be purchased as needed.

Production operations. This includes the costs of production administration, maintenance, and teleteachers. These costs are assumed to remain constant, in real terms, at their respective 1972 values of $220 000, $120 000, and $104 000. In the first 3 years of the project these costs are assumed to be proportional to the number of grades covered.

Transmission operations. Since transmission time is donated, this figure reflects an estimate of the costs of broadcasting 1080 hours annually on a system of the same size and power as Channel 5. Lower costs in early years reflect the reduced hours of broadcast resulting from fewer grades covered.

Reception equipment. The price of a television receiver is assumed to be $280, which is somewhat high so as to include the cost of antennas, where needed. The number of receivers needed is assumed proportional to the number of students enrolled, with the average class size estimated at 23 students.

Reception equipment replacement. This assumes a 5-year life for television receivers.

Reception maintenance and operations. The cost of maintaining and operating the reception equipment each year is assumed to be 10 per cent of the total costs of reception equipment in operation in any year.

Number of students. Prior to 1973 the actual number of students in the system is utilized. It is hypothesised that after that time enrollment grows at a rate of 5 per cent annually.

Klees attempted an assessment of the specific impact of the Telesecundaria system by using regression analysis to allow for a large number of variables. These included community characteristics, student background, attitudes and aspirations, teacher education, experience and classroom behaviour and class size. He found that television was still a significant contributor to student learning for both low-ability and high-ability students.

Conclusion

Telesecundaria is an interesting project in a number of ways. Unlike most projects of this nature it was established and developed by the education authorities of the country concerned without the help of outside funding. As Jamison and co-workers (1976) point out, this may have been an important factor in ensuring its costs effectiveness.

The evaluation of the project has been a rigorous one on both the costs and effectiveness side, and whilst it is always possible to be more rigorous, particularly in effectiveness evaluation, some useful results are available. On the costs side Telesecundaria is able to educate secondary students at a significantly lower cost than the traditional system would involve. The costs analysis indicates also how this advantage largely arises, namely through the use of technology to substitute a low resource cost for a more expensive one. Moreover it would seem that the educational levels achieved by Telesecundaria are equal to, if not better than, those achieved by the traditional system. This is particularly the case if the special characteristics of the Telesecundaria group are taken into account.

Finally the objectives of the evaluation were not simply to indicate which system performed best, but to identify the successful and unsuccessful components as a guide to further action. As Mayo and co-workers state:

> An evaluation is not simply the gathering of a large amount of data from several systems. Once assembled and examined, the basic purpose of an evaluation is still unfulfilled. Decision-makers must see how the conclusion of the study points to realistic actions that can be taken to change and improve the system of instruction (Mayo *et al*. (1975), p. 225).

7.6 THE NICARAGUA RADIO MATHEMATICS PROJECT

Introduction

The Nicaragua Mathematics Project began in 1975, organised largely by the

TABLE 7.7 Average costs of the ITV components of Telesecundaria from year *i* to year *j* (interest rate = 7.5 *per cent*)

	To year j									
	1968	*1970*	*1972*	*1974*	*1976*	*1978*	*1980*	*1982*	*1984*	*1986*
From year i										
1966	198	59	39	33	30	28	27	25	24	23
1969		33	26	24	23	22	22	21	20	19
1971			20	20	20	20	20	19	18	18
1972			18	20	20	20	19	18	18	17
1973				21	21	20	19	18	18	17
1974				21	21	20	19	18	18	17
1975					20	19	19	18	17	17
1976					20	19	19	17	17	16
1977						18	18	17	16	16
1978						18	18	17	16	16
1980							17	15	15	15
1984									15	14

Institute of Mathematical Studies in the Social Sciences at Stanford University and sponsored by the USA Agency for International Development. The project has been evaluated at different stages, resulting in a number of publications. These include Searle *et al.* (1976, 1977a, and 1977b) and Jamison and McAnany (1978). This analysis is based on these reports which should be consulted for fuller information.

Project details

The project is located at Masaya, Nicaragua, which has an area of 543 square kilometres and a population of about 94 000, some 30 000 of whom live in the city of Masaya itself. The project is designed to teach elementary mathematics to primary-grade children. It began originally with first-grade and second-grade classes and during 1977 the programme was extended to the third grade. The evaluation reported here relates to the experiences with the first grade during 1975 and 1976.

The project assumes responsibility for all the mathematics instruction children receive. A daily lesson consists of a 20-minute radio presentation, followed by approximately 20 minutes of teacher-directed activities, for which instructions are contained in a project-developed teacher's guide. No textbooks are used and printed material is limited to a one-page worksheet for each child each day.

A key pedagogical element in the project is frequent student response.

TABLE 7.8 Annual cost per student of Telesecundaria versus direct teaching[a]

	Direct teaching ($)	*Telesecundaria ($)*
Traditional Components[b]		
Administration	6	6
Classroom teachers[c]	203	88
Facilities – fully equipped classroom	11	11
Student costs – books, uniforms, etc.[d]	28	20
Sub-total	248	125
ITV Components[e]		
Production	0	18
Transmission	0	2
Reception	0	4
Sub-total	0	24
TOTAL	248	149

[a] More detailed information concerning the basis of these cost calculations may be found in Klees (1975) Table III.1, Table III.5, and Appendix A; and in Mayo *et al.* (1975) Table II.3, Table II.7, and Appendix B.

[b] Administrative and classroom facility costs for both systems are equal to those given for the Telesecundaria system in the two sources above.

[c] As stated in the above sources, traditional system secondary school teachers earn $4680 per year while Telesecundaria teachers are drawn from the ranks of primary school teachers and earn only $2016 per year. Cost per student estimates assume an average class size of 23.

[d] Students and their families pay the costs of books, supplies, and uniforms. Uniforms cost $4 per student in either system. Books for the Telesecundaria system are $8 less per student than those used for the traditional system; the latter uses general textbooks, while the former uses books especially prepared for and keyed to the instructional television lessons.

[e] These costs assume 29 000 students in the system as in 1972 and a 7.5 per cent social rate of discount.

Before the broadcast each child is handed a worksheet on which he writes his name. During each lesson two main characters join with one or two subordinate characters to sing, play and talk mathematics, usually inviting the children to join in. The children are asked to respond orally, physically, and in writing and they do so 40–50 times during each 20-minute lesson.

Sometimes children handle concrete materials during the broadcast, for example counting or grouping small objects. Dialogue between radio characters introduces new mathematical material and children are asked to respond orally. In later lessons the same exercises are repeated and children respond individually on their worksheets. After the radio transmission, the teacher continues the lesson, following the directions given in the teacher's guide. Usually children will continue working on the worksheet during this period.

Project objectives

The research and development of the project is designed to cover three main areas; namely the relationship between radio and educational achievement, the economics of using radio as a medium of instruction; and the generalisability of the results to other settings. All the areas are major themes of this book and it is indeed unusual to find a project which explicitly sets out to provide such a comprehensive set of information. The emphasis in the early stages of evaluation is on the first area, the relationship between radio and educational achievement, and it is this which is reported on here. However, work has begun on both the other two areas and although few results are available in the 1976 and 1977 research reports, some cost details are given later.

The relationship between radio and educational achievement covers questions such as: Can mathematics be taught effectively using radio as a primary source of instruction? How are achievement gains related to student characteristics? How does achievement of students' learning by radio compare with learning in the conventional classroom? How does the instructional programme affect student and teacher attitudes towards mathematics, towards school, towards learning by radio? Do attendance and dropout patterns change when radio instruction is introduced in the classroom? Does the failure rate attributable to mathematics change? Does poor performance in other school subjects change? The bulk of the projects research budget is devoted to seeking at least partial answers to these questions, although the early studies reported here only cover some of them.

The project is thus significant because it is not just concerned with comparing radio with other media but in examining the particular characteristics of radio which makes it a successful medium of instruction. It is a developmental as well as a research project. Thus evaluation is in two phases. In Phase A lessons are presented in a small number of classrooms and evaluation efforts are concentrated on improving the quality and effectiveness of lessons. During Phase B lessons are broadcast to a larger number of classrooms and the evaluation is directed towards a comparison of the effectiveness of the radio instructional system with traditional instruction.

A stratified random sample of classrooms is assigned to the experimental treatment, and a random set of control classes, similarly stratified, is also selected. Both experimental and control classes are pre- and post-tested, using mathematical achievement tests. As the project lessons are based on the mathematics curriculum designed by the Nicaraguan Ministry of Education, both experimental and control classes can be expected to have studied roughly the same material during the school year, allowing for a comparison of mathematics achievement of the two groups.

Examination results

During 1975 Phase A evaluation took place for first-grade children whilst during 1976 Phase B evaluation took place for first-grade children and a start was made on Phase A evaluation for second-grade children. The results available are for Phase A and B evaluation for the first grade.

Phase A evaluation covered 150 first-grade mathematics lessons which were shown daily in 16 classrooms. Student performance was assessed by means of a pre- and post-test and the tests were also given to nine classes not using the radio programme as a control group. The major objective of the Phase A evaluation was curriculum development rather than comparison between experimental and control group. The sample size was small and the selection of experimental classes was not random. However the results are of some interest and Searle *et al.* (1976) report that the experimental group achieved a mean percentage correct score of 67.3 (standard deviation 23.8) whilst the control group achieved a mean of 55.3 (standard deviation 21.4) For 50 of the 88 items the percentage score for the experimental group was more than 10 points higher than that for the control group. On the basis of the Phase A experiment Searle *et al.* (1977b) concluded:

1. Children are most attentive to radio lessons when they are responding actively.
2. Mathematical activities are more engaging than stories for first-grade children.
3. Children listen to instructions and, in most cases, repetition is not needed.
4. Children can learn new topics from the radio lesson.
5. Teachers are able to incorporate radio lessons into their daily routine.

The more thorough Phase B evaluation was reported on by Searle *et al.* (1977a). This covered 30 classes and 511 students in the experimental group and 23 classes and 438 students in the control group. The test ranged over 84 items and there was a 25 per cent difference in mean item scores between the two groups. The experimental group scored 65.6 per cent correct (with standard deviation 19.9) whilst the control group scored 40.6 per cent correct (standard deviation 18.9).

The evaluation of the Nicaraguan Radio Mathematics Project is in its early stages, but Jamison and McAnany (1978) have concluded that

> we are aware of no other educational intervention in a low income country that has resulted in achievement gains of this magnitude, including interventions making extensive use of television. Future reports not only on educational achievement but on the other major areas of economics and generalisability will be studied with great interest.

Cost Analysis

Just as the evaluation in the early years has concentrated on the effects on the first and second grade, so the cost analysis has had to study the initial experiences. The figures therefore may not be typical of what will eventually result in Nicaragua but they are a good example of the use of cost functions.

Costs are incurred in a number of different activities and these can be subdivided as follows:

(*a*) Start-up and ongoing administrative costs.
(*b*) Programme preparation costs.
(*c*) Transmission costs
(*d*) Reception costs:
    (i) radio equipment;
    (ii) supervision;
    (iii) teachers' guides and training;
    (iv) students' costs (paper, notebooks).

In each of these areas some costs will be for capital items and some for recurrent items. The capital items are annualised through the use of appropriate discount rates and assuming a particular life to the equipment (see Chapter 6) so that all costs items are expressed as an annual charge. Cost functions relate the movement of costs to the movement of output, so it is necessary to identify the output which is to be measured. At the simplest level this would be student numbers, and Jamison and McAnany provide a cost function in which all costs which are not affected by student numbers are regarded as fixed. This would include items (*a*), (*b*) and (*c*) above, since the cost of preparing a given number of programmes and transmitting them does not depend on the number of pupils who will eventually watch them.

In calculating these fixed costs, however, it is necessary to be explicit on the range of output for which they stay fixed, or in other words the short-run period. In this case Jamison and McAnany assume a capacity to produce 150 lessons per grade over three grades.

The costs which do vary with student numbers are those shown under (*d*) above, and putting these together Jamison and McAnany calculate a costs function of:

$$TC(N) = 169\,200 + 1.64N \text{ (in 1975 US dollars)}$$

where N = student numbers
TC = total costs.

With 40 000 students in each of the three grades, the total costs would be $366 000 per annum and the average cost $3.05 per annum. With the average cost well above the marginal cost of $1.64 per student, the cost functions indicate that there are still substantial economies of scale to be reaped by increasing student numbers. Thus, for example, an increase of 10 000 students per grade (i.e. 25 per cent), would add $49 000 or about 13 per cent to total costs and reduce average costs to $2.77 per student per annum.

A more detailed costs function is provided by Jamison *et al*. (1976). Their data unfortunately are based on only the first two grades in the early years of the project, and are therefore a little out of date. It is, however, still a useful example of how a more detailed breakdown indicates the costs implications of pursuing different options. Jamison and co-workers (1976) separate out two outputs, i.e. programme hours as well as student numbers. Thus only item (*a*) above is regarded as a fixed cost. Programme preparation and transmission costs depend on the number of hours of programmes produced, whilst the costs that depend on student numbers are similar to those given in the previous study. The basic difference is costs which were regarded as fixed in relation to student numbers. These can now be seen to vary with programme hours. Thus this function is:

$$TC = F + V_n N + V_h H$$

where F = Fixed Cost
$V_n N$ = Variable costs in relation to student numbers
$V_h N$ = Variable costs in relation to programme hours

The data used by Jamison *et al*. produced a costs function of:

$$TC = 73\,400 + 141h + 3.1.N.$$

As stated previously the data are less reliable than that provided earlier and it will be noticed that here each extra student is calculated to cost 3.1 dollars whereas a more up-to-date assessment is that this figure has been halved. However, by using this function with more contemporary data the effects of varying both the number of programmes and the number of students can be assessed.

8 Conclusions – Effective Media Use

8.1 INTRODUCTION

The analysis in this book has generally been optimistic. It was argued in Chapter 1 that the long-run tendency for teacher costs to rise and media costs to fall would lead to increasing media use in education. The projects reported on in Chapter 7 are all, in their own way, remarkable testimony to the confidence of educationists, media practitioners and decision-makers, in the relevance of media to the solution of educational problems.

Yet there are also reasons for a sense of unease; a feeling perhaps that the 'golden age', if not already over, is coming to a close; that whilst the potentiality of media is clear and proven the reality is more obscure. It is these central questions of the gap between potential and actual media use and the problems of using media effectively which are the concern of this final chapter. First, however, it would be useful to summarise the major theme of the book, the attempt to define the scope and role of economic analysis in media decisions.

8.2 THE SCOPE OF ECONOMIC ANALYSIS

The 'costs imperative' that will make media use more financially attractive in the future will also demand more searching economic analysis both prior to and subsequent to decisions. But what exactly is meant by 'economic analysis' and what part should it play in media decisions?

One approach to defining the scope and limitation of economic analysis is to relate it to the objectives of media use. If the purpose of introducing media into education is economic then it is argued economic analysis is appropriate. However, if there are wider objectives then economic analysis has a limited role, or no role, to play.

A moment's thought will indicate that such an approach is not only simplistic but misleading, for it is possible to claim that any media scheme or project is introduced for non-economic objectives. For example, a closed-circuit television system may be introduced on campus with the intention of allowing enrolments to increase without increasing staff costs. The objective is primarily economic – to increase outputs at a faster rate than inputs – yet it could be claimed that the major purpose was to increase opportunity, to allow more students to enrol than could otherwise have done so.

Indeed the distinction in the objectives of media use made in Chapter 1, between expanding opportunity, increasing quality, and reducing cost, is not very helpful for it implies that economic analysis is only relevant to the last-named, whereas almost all media use can be justified in terms of the other two objectives. If the use of media in education is all about expanding opportunity and increasing quality, and economic analysis is only relevant to reducing cost, there is little to say.

This is not the case, however. Take the objective of expanding opportunity. There is rarely a situation in which this literally means 'the *only* way of providing this educational opportunity is through the use of media'; what is usually meant is that media are the *best* or *most appropriate* way of providing this opportunity, and further investigation reveals that 'best' often implies 'at cheapest cost'.

To return to the closed-circuit television example it would clearly be possible to expand opportunity by allowing more students on campus to study through conventional methods. The closed-circuit television method allows the opportunity to be expanded more economically. In Chapter 7 a number of media projects are analysed and all of these include in their objectives the expansion of opportunity. Yet to greater or lesser degrees what is implied is the expansion of opportunity *more economically*.

The SURGE project in Colorado provides videotapes of on-campus lectures to students off-campus at their place of employment. It would be possible to provide traditional on-campus education for these students but it would involve greater cost to the institution, student and employer. All benefit economically through the videotape system.

The Telesecundaria system in Mexico is designed to overcome the lack of opportunity for secondary education, particularly in rural areas, by providing the standard curriculum through television. Yet if sufficient resources had been available it would have been possible to expand conventional secondary education into these areas. The Telesecundaria system provided a means of achieving the same objectives more cost-effectively.

Even the Open University's claim to a clear and unsullied objective of widening educational opportunity through the provision of higher education to adults can be challenged. For if indeed it was the objective of policy-makers to provide this opportunity, alternative methods to the Open University approach are available. These include, for example, the expansion of the London University external degree system; the possibility of expanding adult opportunities for part-time study in existing higher educational institutions; the establishment of new locally based institutions, specifically to cater for this group; or the introduction of a system of paid educational leave to allow adults to study full-time. The Open University approach using modern developments in media to allow adults to pursue higher education without disturbing their existing employment and family arrangements was seen as the most appropriate, and although economic factors did not play a prominent part formally in the original decision they underlay many of the discussions.

The only situation in which economic analysis is not possible is when there is no alternative to a particular method of achieving an objective. Where alternatives are available an economic analysis of the different costs and benefits is relevant. Indeed even in a situation in which a media approach is the only one available a choice still has to be made between two different media. The Open University may be the correct approach to adult higher education, but the appropriate media mix must still be chosen. Using media to provide rural secondary education may be appropriate in Mexico but the scale, size and mix of the different media must still be decided. In all these decisions economics has a part to play.

So an economic analysis is still relevant, even where the sole objective of media use is to expand educational opportunity. Similarly where the stated objective is to improve quality this does not remove the need for an economic analysis. For the quality variable is in essence the benefit side of the cost–benefit calculus of an economic analysis. There are of course severe practical problems in attempting to measure benefit or quality improvement quantitatively, as the analysis in Chapter 4 indicates, but it is important to recognise that objections to the use of a cost–benefit approach rest on these practical problems rather than any issue of principle.

Thus when it is claimed that closed-circuit television in science and medical studies enables all students to see experiments and operations more clearly, one might expect these improvements to be reflected in improved student performance or satisfaction with the course. Nor is it necessarily very difficult, albeit at a relatively unsophisticated level, to find some measure of this improved quality. In most cases, however, no attempt is made, the statement of improvement is held to be obvious with the result that the most general observation to be made about media projects designed to improve quality is that they may or may not improve quality but they certainly increase costs.

The third objective mentioned in Chapter 1, of reducing cost, is clearly appropriate for economic analysis but from what has been said earlier relating the scope for economic analysis to the objectives for media use is not regarded as a fruitful approach. Whilst care must be taken not to push economic analysis into areas where it is not appropriate the objective approach goes to the other extreme of attempting to exclude it from most aspects of media use. Specifying that the objectives are non-economic does not rule out the relevance of an economic approach.

So what then is the scope of an economic analysis? In the widest sense such an analysis is a framework and methodology for bringing together in a systematic fashion the costs and benefits of any activity. However, this is not to claim that all costs and benefits established within such a framework will be economic or at least financial. Most costs are financial but there may be other costs such as teacher dissatisfaction which might need to be taken into account. On the other hand most benefits are non-economic, as was discussed in Chapter 4.

So it is important to use the framework of an economic analysis in studying media use in education; to begin with an approach to identifying and measuring all the costs and benefits of such use. It is this methodology which is one of the most important insights economics can bring to media decisions. In practice not all costs and benefits will be capable of identification and measurement and not all those that are will be expressed in economic or financial terms. This is the limitation of the economic dimension and the weight to be given to it will depend on the context of any economic study. It is important always to remember that what cannot be identified and measured may be just as important as what can. However, it is to the advantage of an economic analysis that it helps to make any such qualitative areas explicit rather than confused with costs and benefits that can be quantitatively evaluated.

In practice economists have left the evaluation of benefits to others, notably educational psychologists, and have concentrated on the costs end of the equation and on bringing together the psychologists' measurement of benefit with their own assessment of cost. In many cases a measure of benefit has not been available and economic studies have concentrated exclusively on the costs side, assuming implicitly or explicitly that the educational benefit of a media scheme has been at least equal to the benefits of conventionally provided education.

It is important to remember this assumption when assessing evaluation of media schemes that concentrate exclusively on the costs side. For a costs comparison between two systems on its own can only indicate which is cheapest. Unless there is some assumption about benefit, there is no indication which is the most efficient or best economically.

Nevertheless costs analysis of many different media projects have been fruitful and enlightening. They have provided information on the size and nature of the costs of such projects and offered insights into the costs implication of different strategies.

What do we learn, however, from studying these projects in retrospect? Very little in terms of general conclusions about the costs per unit of output of different forms of media. The most that can be given are very broad ranges of figures which offer very little practical guide to any future decision. Apart from changes in price levels and technology there are two important reasons why general conclusions are of little guide. First is the importance of output as a determinant of unit cost. Every educational system and method has some element of economies of scale by which unit costs fall as output increases. It is always possible to increase class sizes in conventional education without increasing costs proportionately. In media education the scale effect is far greater and the impact on unit costs of running the system below capacity is significantly larger. So to be told the unit cost of using a particular medium – e.g. television – in a particular system is of little practical help unless one is given further information about the scale of output in relation to the capacity of the system. We may be told television costs $10 per student contact hour, but unless we know the production capacity of the studio, the transmission capacity, and the number of students and their hours of viewing, we are being given useless information on which to base any decision about any other system using television.

The second reason why a general conclusion will be of little guidance is the difficulty of establishing an identical system to the one being studied. This lies at the very heart of the problem of media choice described in Chapter 2. For the essence of this choice is that it must be education- and not media-based. The establishment of a system of media-based instruction which starts, from the educational needs of the system and not from any preconceived ideas about using particular media is unlikely to produce a media mix of similar type and scale to any other. The correct method of establishing media systems precludes their being taken 'off the shelf'. They have to be purpose-built to meet the particular needs of the project in question. It is unlikely, therefore, that the results of one project can be simply or directly applied to another.

The study of existing systems as a guide to future systems has wider objectives. First is to understand the key factors in success or failure. Whilst different media systems will all have their unique characteristics the principles of success or failure are likely to apply equally. In terms of costs analysis the lessons to be learnt from other projects include the following:

(a) the temptation to under-estimate initial costs and over-estimate student usage at the central planning stage;
(b) the importance of student usage as a determinant of unit cost;
(c) the costs advantages of flexibility in devising systems which can be augumented or reduced relatively easily.

A second key element in the study of existing systems is an indication of the insights costs analysis can provide into the costs nature of a project. The use of total, average and marginal cost functions, particularly those of a sophisticated nature, enable decision-makers to see the costs implications of alternative decisions, the funds committed irrevocably over time, the losses sustained if the project is aborted or killed at any stage, the costs of expanding or reducing the project at any stage and the contribution to costs of the different components of the media mix. This is where costs analysis makes its own unique contribution to the understanding of media systems and it is for this reason that those involved with existing projects and those proposing new ones should not seek simple guidelines on the likely cost from the results of previous projects, but should apply the methodology of these previous efforts to provide tailor-made answers to their own particular needs.

8.3 DECLINING MEDIA USE

The explosion in the use of media in education in the 1960s and early 1970s, referred to at the beginning of the book, has shown signs of slowing down in the last few years. Partly this is an inevitable reaction to the rapid expansion of the earlier decade. A period of consolidation and absorption is now required. It is also partly a reflection of the more stringent economic circumstances of the latter half of the 1970s. The developing countries have long been used to the inadequacy of their resources to meet their economic and social aspirations. The use of media in education in these countries has inevitably been in aid programmes from individual countries such as the USA, and international agencies such as the World Bank and UNESCO. Since the end of 1973 the industrialised, developed economies have also had to live with a situation where oil and energy costs take a greater share of resources, leaving less for other activities such as education. The management of these economies during this period has also been a contributory factor but the overall effect has been to produce an environment not conducive to the experimentation and innovation which media use in education implies.

There is a third factor influencing this slowdown which has claims to being the most important, and this is the disillusionment with the ability of education in general and educational media in particular to meet the needs of society. The interest of economists in the contribution of education to economic growth was discussed in Chapter 1, and it will be noted that most of the studies referred to were published in the early 1960s. This was the period in which the interest in, and search for, the causes of economic growth was at its height. It applied to all areas including both the reasons for the gap between the rich and poor countries as a whole and how the gap might be narrowed, and the differences in the growth rates between the various rich countries themselves. Education and the investment in human capital as an analogue to the traditionally accepted need for investment in physical capital came to be seen as an important determinent of economic growth.

It is significant for example that the Robbins Report on the future of higher education in the UK, published in 1963, included a study on the contribution of education to economic growth.

It is not pretentious or over-ambitious of economists to claim that these studies and the intellectual environment they provided were an important factor in the rapid expansion of resources in education in the 1960s. The developed world had experienced nearly 20 years of post-war prosperity with reasonably full employment, low inflation and stable exchange rates. The problems were, as it was put at the time, 'the problems of success'. The concern was not the dangers to prosperity but the ways in which this prosperity could be improved and enlarged. And with an impressive unity amongst economists on the relevance of education to the achievement of this objective it is not surprising that the politicians pushed ahead in this direction.

However education became not just the panacea for growth but for other social objectives such as the desire for greater equality, or to be more precise, less inequality. To some extent this argument for the role of education was an extension of the growth argument; for if education increased the rate of growth this was reflected in higher earnings for those with higher educational qualifications. Therefore not only should there be an increase in the number obtaining these qualifications but everybody should have an equal chance to obtain them. Equality of educational opportunity was not only a moral right but a method of reducing income inequality through increasing the numbers obtaining higher incomes within the growing cake. As sociologists and psychologists joined the argument to show that equality of opportunity did not necessarily imply equal resources but required positive discrimination to help those deprived in the non-school environment to overcome their handicaps, so the resources poured in.

Heightened expectations inevitably lead to over-reaction in disappointment. It may not be education's fault that the fall-off in growth rates coincided with the expansion of education. Even if politicians understand intellectually that correlation is no indication of causation, the temptation to make the simple judgment and find the scapegoat is a great one. So as growth rates fall and resources become squeezed, education if not positively discriminated against is certainly no longer the favoured child.

The disillusion or at least falling-off in enthusiasm for educational media is partly a reflection of this more general disaffection with education. But there are some reasons specific to educational media themselves.

Just as education might have been oversold in the sixties, media too had its enthusiasts. In an atmosphere in which resources were relatively plentiful but where decision-makers had little practical knowledge of media applications to education it was understandable that advocates would claim that all the benefits media *might* bring would actually occur. So it was argued that media would widen access, improve quality and reduce costs all at the same time. The inability of performance to live up to promises of this nature has inevitably increased scepticism about both the potential and actual usefulness of media in education.

On the costs side the particular characteristics of media systems made cost estimation much more difficult than for traditional systems. In the latter case, say the establishment of a school or college to teach in the usual face-to-face method, the demand for the new institution is usually known beforehand. Indeed its establishment is often a response to these demand pressures. The costs can usually be reliably estimated because past experience is available of similar types of institution which have been built in the recent past. And the overall initial cost commitment need not be too large. A certain minimum size is needed, but it is possible for the first phase to be reasonably small with resources being added as demand expands.

Costs estimating of media systems faced completely different conditions. As has been discussed in previous chapters media systems change the production function of education by substituting capital for labour. A high initial fixed cost is offset against the low variable cost of adding students to the system. As a result media systems invariably involve a high initial cost commitment. This is compounded by the fact that certainly in the 1960s and early 1970s there were few existing models on which cost estimates could be based. Every project was a journey into the unknown. This also applied to the demand side. Unlike traditional systems introduced to meet known demand media systems generally catered for new areas of demand which by their nature were uncertain, particularly those in the higher education sphere, which could not rely on compulsion to provide a captive audience.

The uncertainty of costs and demand estimates was allied to the need for high initial costs to be offset by large demand to bring down average costs. It is not surprising if in these conditions costs were under-estimated and demand over-estimated to produce average cost per student estimates that compared favourably with traditional systems. This was not a matter of deceit on the part of the estimators. Rather in areas of great uncertainty where any estimate had to be given in terms of a fairly wide range of figures it was understandable if media enthusiasts took the lower end of the range in their costs estimates and the upper end of the range in their demand estimates. This is what Carnoy and Levin (1975) identified as the 'benefit of doubt bias' in media evaluations.

Moreover the temptation to indulge this bias in order to establish a media system was compounded by the fact that, once the system was in operation, however great the discrepancy between forecast and actual initial costs, the low variable costs invariably implied it was worthwhile expanding the system or at least keeping it in operation. With both total costs and average costs in practice rising well above the levels estimated, the jaundiced view of decision-makers to the claims that media would reduce costs is easy to understand.

However over-optimism on the costs side is only part of the answer. On the effectiveness side even where claims have been realistic and modest they have often not been realised. What has been lacking in many cases has been a fundamental understanding of the requirements for effective media use.

8.4 EFFECTIVE MEDIA USE

Much has been written in recent years on the necessary conditions for introducing media effectively into education. At the small-scale level of the individual item of equipment in a particular institution, it may often boil down to inadequate training of staff to use the machinery effectively, and a lack of maintenance staff to service equipment. The locked cupboards of unused audio-visual equipment in schools may be a legend, but there is some evidence of its basis in fact.

With larger systems perhaps the pithiest statement was made by Andrew Molnar, who summarised the reasons for educational media in general and computer-assisted learning in particular not achieving their potential as 'research but no development, equipment but no materials, market but no customer, economy and autonomy of teachers, money but not enough, and programmes but no system' (Molnar, 1970).

Many of these factors are interrelated. The autonomy of teachers, for example, may be a partial cause of the existence of equipment but no materials. Another approach is to identify the different levels at which decisions about media use have to be made and to analyse the factors relevant at each level. Thus it is possible to distinguish between the national, institutional and course level.

At the national level major decisions about the use of media to cover a whole system are made. The Open University, Mexican Telesecundaria, and Nicaraguan Radio Mathematics projects, are examples of the results of decisions at national level. Without adequate political and financial support and muscle these projects would never have been established or, in some cases, sustained through difficult circumstances. A project which is the product of partisan support may be in danger through no fault of its internal efficiency and effectiveness. The Open University in the UK was conceived and established by a Labour Government. Less than a year after its formal foundation, and before any students had been enrolled, a Conservative Government came to power and the University was under threat. It required some adroit political work by the University's leaders to avoid the axe and ensure the continuation of the project (see Perry, 1978).

At the institutional and course level the teacher is the centre of the instructional process. The introduction of a media system inevitably produces institutional change, and it is the challenge of this process to the traditional role of the teacher which is the key to many of the problems of effective media use. For traditionally the teacher is autonomous in the classroom. His curriculum may be externally determined either through examination syllabuses or through other controls. However he will generally have great freedom in choosing the means by which these curriculum ends should be achieved, both overall and in the details of pacing a lesson, mix of different learning materials, substitution of materials and content between lessons, pupil and student assessment and so on.

Media challenge this autonomy. Other professional values are involved and the teacher has to accept the help of others in the instruction process to a far greater extent than previously. Even at the simplest level this can mean quite a change. For example consider a situation in which lectures are to be videotaped or televised live for a wider audience. There is no challenge here to the lecturer's autonomy over the content of his lecture and yet he still faces significant changes to his way of working. He will have to learn to focus his attention on a particular spot (the camera) for greater periods of time than he is used to; any writing on the board will have to be clearer; the lecture will require greater structure and he will have to keep to his timetable much more rigorously. Even with this type of media use it has been found that staff require between 50 and 100 per cent more time to prepare.

At the more sophisticated level where television, radio or tape are used, not just for their transmission advantages but to incorporate their production values as well, the problems are much greater. Now the teacher may find himself in a studio with producers, assistants, lighting engineers, cameramen, sound engineers, animators and designers, all professionals in their own field and all feeling they have something to contribute to the quality of the final product. The teacher as writer and presenter (and even these functions may only be his in part) is now part of a team. He must both forego some of his traditional roles and learn new skills. It is a new experience and whilst some may see it as exciting and glamorous, others see it as a threat. They are no longer in control of the educational process. In any event the excitement and glamour eventually wear off and the reality of the relationship with others remains.

This need to share the stage with others exists both in institutions into which media are introduced and in those specifically established to use media. At the Open University the tension between academics on the one hand, and editors and designers of the written materials, and producers of the broadcast programmes on the other, is ever-present. For whilst these different groups of individuals have all been brought together to serve the needs of the institution the reference point for their value-systems of what is correct and appropriate is their own peer group. The academic will wish to ensure the accuracy and rigour of what has been written, the editor will wish to see clear English written in a good style, the designer will wish to show his illustrative skills to their best advantage, and the producer will wish to create 'good' television which may be variously described as 'lively', 'compelling', 'viewable', etc.

By some good fortune these different values may be found to be compatible, but more often than not there are differences of opinion which have to be resolved in the give-and-take of a team-based approach. Nor should these differences be seen as the result of some bloody-mindedness or pig-headedness on the part of the participants. It is an inevitable result of the system. Each of the participants, whilst subscribing to the goals of the institution, is also concerned with his own career development. The academic wants to ensure that anything under his name is acceptable to his academic peers; the designer might not see himself spending the rest of his working life in the institution and requires a good portfolio of drawings to show any future prospective employer; the producer may hope some day to enter the general educational television service, or indeed the general service, and will take his production values from there. Conflicts of interest are inevitable between the teacher and those he now requires to help him teach.

This problem, of course, is one of the teacher's role compared to others and it presupposes that the teacher's role has been accepted. At the Open University, whilst these tensions exist, the academic's pre-eminent involvement in the educational process is understood and accepted. In other systems this may not be the case and it is assumed that because television is being used it is those practised in the skills of television who should dominate. Lyle-Nelson, in discussing the well-known American Samoa television project observed:

> instead of starting with educational needs and objectives and then asking what part instructional television might play in meeting them, what was done in Samoa was essentially to design a new curriculum for television. As a result, the role of the classroom teacher was downgraded, very much so, with predictable results. The classroom teacher – by far the most important factor in any learning process – became at best an ancillary element and at worst an unwilling and negative participant. It is significant, I think, that in the early stages the project was in the hands of broadcasters and not curriculum specialists (Armsey and Dahl, 1973).

If media systems are to be successful teacher support is essential. Partly this is a result of the political power of the teaching profession. Even systems which did not require active teacher participation would find it hard to gain acceptance against teacher opposition. Where teacher involvement is required success without their support is not possible.

The key to the essential nature of teacher support is not some abstract political power but the teacher's central role in the curriculum. One of the reasons given earlier by Andrew Molnar for the ineffective use of media was the existence of equipment but no materials. An alternative way of expressing the same problem is the distinction between hardware and software.

There is a danger in media systems in becoming entranced by the gadgetry. The power of television or film to create images, the use of colour, the ability to go on location, to produce close-ups, to bring well-known personalities and world-wide authorities into the classroom, to dramatise rather than describe, all open up new approaches to instruction. The developments in computers to increase memory capacity, to link to visual displays, to increase terminal capacity, and so on are all very important; but in the end they are simply machines with a potential use in education. What translates the potentiality into reality is the quality of the software which is developed to be used by the machines. Television cameras and receivers are only as effective as educational media as the programmes they produce and transmit. Similarly the effectiveness of computer systems depends on the programmes and instructional materials developed. And without teachers the ability to produce effective software is seriously diminished.

Even with teacher support it is not that easy and teacher involvement must be seen as a necessary but not sufficient condition for effective media use. The place at which the teacher becomes involved is also important. In some instances the teacher is asked to design curriculum materials at the end of any planning process.

The first stage has been to choose the media, and only then are the educational goals formulated and curriculum materials developed. The use of media becomes the goal of the system and instructional means are devised to serve media ends instead of the other way round. As was argued at length in Chapter 2 the starting point for any decision about media use is the educational objective not the media available. Choice of media comes at the end of the decision when the educational objectives and tastes have been defined.

It is not just a question, however, of ensuring that teachers are involved at all stages and that the design of the project proceeds along sound lines. The inadequacy of software arises from an inadequate understanding of the particular needs and uses of media as means of instruction. Where teachers have been excluded from producing this software this inadequacy is easy to understand; but simply involving teachers does not solve the problem: the teachers too have to learn anew.

Part of the suspicion of the media by teachers apart from the recognition of its attack on their autonomy, is the realisation that it requires new skills. At one level it involves an enthusiasm and empathy for media in education; at another it requires the commitment and resources to undergo training. And the commitment and resources are not the teacher's alone to provide. Employers at the institutional, local and national level have an important role in providing courses and adequate time for teachers to acquire the skills required.

Inadequate software is a key element in the dissatisfaction with the effective use of media in education; and this inadequacy, it is argued, arises because the teacher's role in the production of this software has not been sufficiently emphasised, either through teachers playing only a minor role in the development of materials or where they play a more significant part, being inadequately trained.

So far the teacher's role in the effective use of media has been discussed in terms of its challenge to his autonomy, the clash between different values in the production of instructional material for educational media, the minimal part teachers often play in the production and their inadequate training.

Finally another important factor must be discussed in analysing the teacher's role. This is the reward teachers receive for their participation in media innovation.

The introduction of a media system into an educational institution involves costs and benefits which are distributed amongst the different participators. From the teacher's point of view the costs of becoming involved with a media system might in the short term be largely those involved in training, etc. In the longer run there may be more serious costs such as reduced employment opportunities. So what incentive is given to the teacher in terms of benefit to persuade him to co-operate and involve himself with the new system?

In industry the process is clear. The rewards of a technical innovation which enables the firm to produce more output per unit of input can be distributed in a number of ways. The price of the product and the wages of the work force can continue at previous levels, the benefit of the improvement being reflected in increased profits to the firm. Alternatively, both wages and profits remain unchanged and prices are reduced to the benefit of the consumer. Finally prices and profits remain unchanged with the workers receiving the benefit in the form of increased wages. Indeed as the increase of output per unit of input often occurs without total output being increased, the implication is a reduction of employment. The increase in wages is then seen as a compensation for this reduction.

In practice negotiation prior or subsequent to the introduction of the new technology results in a distribution of the benefits between the competing interests. Or rather as the consumer plays no general part in the negotiating process the firm and the employees usually distribute the gains between increased profits and wages.

Now in principle it would be possible to apply the same approach to education – particularly the higher-education sector where fees are charged. Indeed the following example is based on the experience at one fee-paying institution in the USA. Here closed-circuit television was used to beam lectures on a particular graduate course live to students in a nearby city, who would follow them at their place of work. The students could interact with the lecturer on a two-way audio system, although the video system was only one-way. The students submitted written material and assignments to the university, which was marked by faculty in the normal way. The off-campus students paid the same fees, sat the same examinations, and received the same certification as their colleagues on-campus. The purpose of using the media was to increase enrolment by allowing students not able to attend on campus to study the course in question. From the institution's point of view the scheme was profitable. The fees of the extra students were substantially in excess of the cost of providing them with the tuition. The costs of using the media were much lower than establishing an additional class for the students on campus. The students benefited through being able to study and obtain a qualification at no extra cost and with minimum disturbance to their employment. The employers similarly benefited from a form of in-service training at low cost and without disruption.

But what did faculty gain? The use of media required time for training and preparation. At first the administration were not even prepared to allow this time against a faculty member's teaching requirement time, so that all other duties remained and the teacher was in fact worse off in having to spend more time in teaching than previously. It is not surprising that staff's reaction to this attitude was to refuse to use the new media the following year. Eventually the benefits were more evenly distributed in that faculty were not only allowed to incorporate preparation time into their total teaching hours, but were allowed extra hours in recognition of the extra number of students taught.

The problem of incentives to faculty participation can be seen more directly with a recorded television or video system where programmes are repeated in subsequent periods. Here there is a direct trade-off for the faculty member in spending extra time to produce the tapes in the first instance against the time saved in subsequent periods from having to repeat the lecture. However if the institution refuses to recognise the repetition of the tape on future occasions as part of the faculty member's teaching load he is worse off than before. He has incurred the extra costs in terms of time of producing the original tape without any offsetting benefits in the reduction of his teaching load in future years.

A similar situation faces the staff member needing to spend time designing instructional programmes for use in computer-assisted instruction systems. Where the programmes will be used by others outside the system a royalty scheme might be established to provide an adequate reward. Where the programme will be used by the staff member on future occasions the question of compensation for the investment of time and effort is once again raised.

The problem is made more difficult by the complex nature of reward and incentive systems in higher education. Unlike the industrial analogy used earlier, much of higher education is not run on market lines. Furthermore where the provision is run close to market lines, as in fee-paying institutions, the payment to faculty members does not follow the same principle. The structure of faculty salaries largely precludes the payment of increased salaries as a reward for introducing innovation.

Traditionally, in university higher education, the faculty member receives a salary for which he is expected to produce a certain amount of teaching and research. In practice the quantity of teaching input is usually precisely specified (hours per week or semester) whilst the research activity is left a little vague. In addition staff are allowed to engage in a certain amount of outside consultancy.

Note that the teaching activity is specified in terms of input rather than output. Given the difficulty of measuring output it is not surprising that the only requirement is a quantitative measure of input. Quality of teaching input or output is not specified. As such there is a built-in bias in favour of research and against teaching, as Layard and Jackman have argued:

> The university will wish to pay its members on the basis of their expected productivity, but how is this to be assessed? It is widely believed that teaching capacity is more difficult to evaluate than research capacity and that an academic's accumulated research is often used as a proxy measure of the potential value of his current teaching and research output. This may be particularly the case when he moves from one university to another. If this is so it introduces an extraneous element into the individual teacher's utility function, for he now values his current research output more highly, relative to his teaching output, purely because of the higher command over future income which it gives him. This in turn will affect the level of teaching load for which he is willing to vote (Layard and Jackman, 1973).

As these authors point out, with this situation it may be asked why even the current amount of teaching is done. They offer three possible explanations: the satisfaction to be gained from the success of teaching (e.g. examination results), the satisfaction to be gained from the teaching input (e.g. addressing an audience) irrespective of any output, and the benefits for research to be gained from teaching. To these must be added a fourth, and in some cases the most important, reason: the external constraints imposed by funding bodies, or the university administration in which funds are provided for a certain level of student numbers.

However, whilst this system ensures that some teaching is done, it provides no incentives for attempts to improve the quality of teaching or for investing more time in teaching without subsequent compensation. Given the system teachers must be encouraged to use media, by being allowed to offset the time costs involved against their other teaching requirements. Where media are used to expand numbers this should be possible without any extra cost to the institution. Where, however, the object of using media is to improve the quality of instruction and output, this will inevitably increase costs as the reward system within the institution makes no provision for improvements in teaching quality.

8.5 THE FUTURE

Predictions are hazardous and nowhere more so than in the area of educational media. There are too many independent variables, the outcome of which is difficult to forecast. The correct position for the 1980s is optimism tempered by caution; optimism because of the positive factors in favour of increased media use. Education will still be in demand in both developed and developing countries and the resource constraints which the world economy is likely to face over the next decade will make the 'costs imperative' of media choice ever more attractive. The potentiality leads to optimism. The reality leads to caution, for the evidence of media experiments and projects over the preceding two decades is that the undoubted successes must be balanced by the equally undoubted failures. The lessons of success and failure must be learnt, the factors making for realistic cost analysis and effective media use in action must be absorbed. One of the great positive gains of the activity of the last decade in particular is that appropriate methodologies and techniques have been established for evaluating media proposals. The task now is to apply them.

Notes

CHAPTER 2: MEDIA CHOICE

1. For a brief description of some of these applications see Beard (1972) and for a more lengthy treatment of a possible application to an economics course see Ryba and Drake (1974).

CHAPTER 3: EFFICIENCY IN EDUCATION

1. This is not necessarily an unrealistic example. In a deflationary situation it would not be unusual for there to be a wages freeze accompanied by a sharp rise in interest rates.
2. Universities are used as a synonym for higher education. The relative importance of the different types of output between universities and polytechnics in the UK and private universities, state universities and junior colleges in the USA is significant, but a discussion of this would divert us from our main purpose. Universities provide the most interesting case because the claim of having a number of different outputs has been made particularly on their behalf.
3. Allowance might have to be made for a slightly increased rental equivalent cost for desks and chairs, some extra examination costs and so on.
4. These factors were all taken into account in the EEP project and are discussed in more detail in Scott (1974).
5. See Bear (1974), for example.
6. The problem with any generalised statement in this area is that there is always likely to be an exception. In this case it can be argued that the media system might have wider community objectives as well as the more narrow student-based ones. The Open University, for example, might claim that one of its objectives was to provide educational programmes for a wider audience.
7. One possible exception to this is the community-centre objective of schools which is related more to what they provide for parents and other adults than for pupils.
8. However, where a media system is being compared with a conventional system an allowance for the other outputs of the latter might need to be made.

CHAPTER 4: MEASURING EDUCATIONAL ACHIEVEMENT

1. Schramm (1973, p. 41) estimated that over 500 experimental studies of instructional media existed in the research literature. Chu and Schramm (1967) evaluated 207 studies on the use of television which involved 421 separate

comparisons. Dubin and Hedley (1969) surveyed 193 studies of the use of television.

2. The argument is usually phrased in terms of 'advanced capitalist industrialised countries' but there seems little evidence that the position is any different in socialist industrialised countries. It is the mode of production not the mode of ownership which is important.

CHAPTER 5: MEDIA COSTS I – COST ANALYSIS

1. See for example studies used in Chapter 7 and also those included in Jamison. *et al*. (1976).
2. Two technical points might be mentioned at this stage. First marginal cost can be expressed as the increase in total costs (TC) as output increases (n). As this increase tends towards zero first-order differentiation calculus can be used to measure the change in costs as output increases so that the equation is expressed as:

$$MC = \frac{dTC}{dn}$$

The benefit of this formulation is that it provides a generalised expression for the calculation of marginal cost.

Because of this link with differential calculus the term 'marginal cost' is often strictly held to refer to the increase of only one unit of output. In other words, marginal cost is the cost of one more student or even one more student contact hour. In reality this is not very practical and it is more likely that the extra cost of a more discrete change in output (100 or 1000) students will be required. In this situation the term 'incremental cost' rather than 'marginal cost' is often used. However, for our purposes the simple term 'marginal cost' will be used for all cases where small changes in output are being measured whether these cover one or more units.

3. Jamison *et al*. (1976) argue that *both* costs and utilisation rate in the years i to j should be discounted to year i. This makes sense for the calculations of costs. If interest rates are 10 per cent then £100 000 in year i is worth £110 000 in year $i + 1$, or put the other way round to allocate £110 000 in year $i + 1$ will require putting aside only £100 000 in year i and investing it till year $i+1$. Thus all expenditures in years after i have to be discounted back to their present value in year i, if the calculation is being made from the perspective of that year. The same principle does not apply to student utilisation in terms of numbers or contact hours and Jamison *et al*. do not explain why they recommend that it should.

CHAPTER 6: MEDIA COSTS II – PROBLEMS OF COSTS ANALYSIS

1. In reality the definition is not as clear as all that. The initial costs of a project may not be its final costs if the project is wound up. Equipment can be sold or used for other purposes, for example.
2. For further details on PLATO IV, see Alpert and Bitzer (1970) and Bitzer and Skaperdas (1969).

3. It is easy to see how the capital/fixed and recurrent/variable relationship is seen as a convenient short cut by some; for recurrent costs by definition recur each year as do the number of students, and thus it is assumed the two are related. As we have seen, however, this is too simplistic and confuses rather than clarifies the relationship.
4. It should be emphasised that the difference between present and future funds is assumed to be in constant prices. In other words any future expected rate of inflation should be added to the time-preference rate of interest. This implies that where the market interest rate is below the rate of inflation, as occurred in a number of economies during the mid-1970s, individuals actually have a negative time-preference rate. They prefer to have less real funds in the future than in the present.
5. Incidentally, from the point of view of 'efficiency' questions, life would be much simpler if one accepted the Marxist thesis that the State rules on behalf of a particular group, i.e. the ruling class. Social investment decisions would only need to be analysed in terms of the alternatives open to this class and not from the viewpoint of society as a whole, and private market rates of interest would be used to measure time-preference and opportunity cost. However such an analysis would leave open the question of equity, i.e. the distribution of any benefits gained rather than their total size.
6. This subject is a complex one and the reader requiring a fuller treatment is referred to Layard (1973) and Mishan (1975).

CHAPTER 7: COSTS AND EFFECTIVENESS ANALYSIS IN PRACTICE

1. The term 'kit' is an elastic one and might include records, tapes, slides, etc., for student home use.
2. Some science courses are divided into one-third and one-sixth credits to enable different courses to be combined into a half or full credit.
3. For further discussion of SURGE see Baldwin (1969), Baldwin and Neidt (1970), Baldwin *et al*. (1972) and Wagner (1975).

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THE ECONOMICS OF EDUCATIONAL MEDIA

The book provides a concise conceptual and practical guide to the economic analysis of media use in education. While the book reviews the evidence on the costs and benefits of educational media, its main orientation is to provide a methodology to guide future decision-making. Thus it includes chapters on establishing a framework for media choice, on evaluating the effectiveness of media use, and on analyzing costs. The empirical evidence from past projects is chosen to illustrate both different types of media projects and different methodological approaches.

Amongst the projects which come under close scrutiny are the Open University in the UK, the Telesecundaria project in Mexico, the Nicaraguan Radio Mathematics Project and the PLATO computer-assisted learning project in the USA. The final chapter draws on the evidence of past projects to discuss why many media innovations seem to fail and what is required to make such innovations more effective, thus turning their potential cost and educational benefits into reality.

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